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It is a pleasure to commend the far-sighted policy of the Office of Naval Research, with its emphasis on basic research, as a result of which a grant has made possible the continuation of the Coral Atoll Program of the Pacific Science Board.

It is of interest to note, historically, that much of the fundamental information on atolls of the Pacific was gathered by the U. S. Navy's South Pacific Exploring Expedition, over one hundred years ago, under the command of Captain Charles Wilkes. The continuing nature of such scientific interest by the Navy is shown by the support for the Pacific Science Board's research programs, CIMA, SIM, and ICCP, during the past eleven years. The Coral Atoll Program is a part of SIM.

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Editorial Staff

F. R. Fosberg, editor
M.-H. Sachet, assistant editor

Correspondence concerning the Atoll Research Bulletin should be addressed to the above

c/o Pacific Science Board
National Research Council
2101 Constitution Avenue, N. W.
Washington 25, D. C., U. S. A.

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Long-term Effects of Radioactive Fallout on Plants?

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Long-term Effects of Radioactive Fallout on Plants?^{1/}

by

F. R. Fosberg

Botanist, U. S. Geological Survey

A number of fallout surveys have been carried out since the widely publicized Castle Bravo bomb test on Bikini Atoll on March 1, 1954. Three of these were under the auspices of the U. S. Naval Radiological Defense Laboratory (NRDL). Among the results of the first of these surveys was the establishment of a series of stations in the Northern Marshall Islands in which the amount of fallout varied, with radiation doses ranging from almost none to doses dangerous to human and animal life. A series of stations selected for subsequent resurvey are listed in order of increasing dose received expressed as total dose to infinity. This figure was obtained from the intensities in roentgens per hour on the day after the shot was fired. These rates were calculated from the earliest actual readings available and are given by Dunning (1957) on a map on page 2. The formula $5 \times 24 \times 4/\text{hr}$ at $D + 1$, where $D + 1$ is assumed to be $D / 24$ hours, is used to calculate total dose to infinity. The time of arrival at Rongelap Islet was about 7 hours after the shot. The time to the other stations can safely be assumed to have been about the same or longer, which would give a maximum error of 22 percent.^{2/}

List of stations:

Likiep Atoll, Likiep Islet		scarcely any
Utirik Atoll, Utirik Islet		33.r
Ailinginae Atoll, Sifo Islet		125.r
Rongelap Atoll, Rongelap Islet		336.r
Rongerik Atoll, Eniwetak Islet		365.r
Rongelap Atoll, Eniaetok Islet		816.r
" " , Kabelle Islet		1824.r
" " , Gegen Islet		3360.r

These figures, of course, say nothing of the proportions of particular isotopes present, except that since 7 hours elapsed before this fallout was deposited, the longer-lived ones will have been relatively abundant, which is a very important fact, physiologically, as it is these which will be responsible for any cumulative effects.

During the first two NRDL surveys no visible effects on plants were recorded, though some of the food plants tested showed considerable accumulation of radioactivity in their tissues.

The author of this note accompanied the resurvey of these islands in February, 1956, in the capacity of coral atoll ecologist, but most of his time was required in helping with the collecting of samples for

^{1/} Publication authorized by the Director, U. S. Geological Survey.

^{2/} Information supplied by Mr. Sam Rainey.

analysis. Because no gross effects on plants were observed on the earlier surveys and since radiation damage to plants was not known at the radiation intensities existing on these islands no provision was made in the planning of the work for time to observe such phenomena. Time was not available for careful study even after it became evident that the vegetation on some of the islets visited was not normal.

Casual observations were recorded, mostly of a general ecological and descriptive nature, in the course of sample collecting. However, until members of the party recognized that the poor condition of the vegetation on Gegen I. had not been evident the previous year, no serious attention was paid to these abnormal phenomena. By this time it was too late to make any systematic study.

Subsequent study of notes and photographs made on the 1956 survey has indicated that suspicion of cumulative effects of radioactivity is justified and that further field study should be directed specifically at this problem. Until specific studies can be made, it seems best to publish the available data, even though they are inadequate either to establish or to disprove any cumulative radioactive effects. Perhaps if attention is thus called to the problem, someone in position to make further observations may be induced to collect data that will settle the matter before so much time has elapsed that all effects are masked.

In a report to the Atomic Energy Commission in 1950 St. John and Biddulph described visible abnormalities of various sorts observed in August 1949 in plants growing within a mile of the site of the 1948 atomic explosions on Eniwetok Atoll. Some of these were interpreted as persistent physiological effects, others as "phenotypic mutants". The plants affected were the following:

Boerhavia diffusa Forst. f.
Cenchrus echinatus L.
Chloris inflata Link
Cocos nucifera L.
Fleurya ruderalis (Forst. f.) Gaud.
Ipomoea pes-caprae (L.) Roth
Ipomoea tuba (Schlecht.) Don
Morinda citrifolia L.
Portulaca oleracea L.
Scaevola sericea Vahl (as S. frutescens (Mill.) Kr.)

The environments studied on the 1956 survey were very similar to those in which the plants studied by St. John and Buddulph grew, but the intensities of radioactivity were many times less.

On the 1956 survey, attention was first attracted by Suriana maritima L., a small-leaved bright green shrub, which showed dead branches or completely dead bushes wherever observed (condition not recorded on Rongelap Islet, as attention had not been drawn to it at the time Rongelap was visited).

Until Eniwetak Islet, on Rongerik Atoll, was visited only casual attention was paid to this phenomenon. Here, however, the Cordia forest

which covers a large part of the islet appeared a dark gray color from the air. This was found to be due to a dying back of the twigs over the entire tops of the Cordia trees for as much as 30 cm. or even more and a complete loss of leaves from the upper parts of the trees. The Pisonia grandis associated with the Cordia was defoliated but flowering, a condition which could be normal in a severe dry season.

On Gegen Islet, Rongelap Atoll, subjected to the most severe fallout, almost the entire vegetation was observed to be in very poor condition. Cordia and Guettarda, two of the most important shrubs, were dead or apparently dying. Pisonia trees were entirely defoliated except for mistletoe-like clumps of abnormally dark green leaves of an appearance not previously seen in this common species. Lepturus repens, the commonest herb, was completely dead except for a few tiny seedling tufts on the beach ridges. All Fleurya ruderalis plants observed were almost dead. Some coconut trees were dead. The other species present, with the exception of Scaevola sericea and Tournefortia argentea, were in unhealthy condition. The latter two species were in generally good shape wherever observed.

The following two lists present the complete observations, so arranged as to bring out any correlation with fallout intensity.

1. Plant species in which abnormal appearances were observed, occurrences by islets in order of increasing fallout intensity.

Suriana maritima L.

Utirik I. - abundant, very few dead or partly dead plants seen.

Rongelap I. - no specific observations recorded.

Sifo I. - mostly healthy but some bushes dead.

Eniaetok I. - mostly dead.

Kabelle I. - many dead bushes, no live ones seen.

Gegen I. - none seen.

(Similar partially dead Suriana was observed in 1956 on Enyu I., Bikini Atoll by Mr. Sam Rainey (personal communication).)

Pisonia grandis R. Br.

Sifo I. - somewhat defoliated but not strikingly so.

Kabelle I. - almost leafless.

Eniwetak I. - leafless and mostly in flower.

Gegen I. - nearly to entirely leafless and flowering, but with compact clumps of abnormally dark green leaves that somewhat resemble mistletoe from a distance.

Cordia subcordata Lam.

Eniwetak I. - appeared dark gray from above, tops bare of leaves, upper twigs dead to 30 cm. or

more from tips, trees generally rather defoliated, more so in west than east half of islet; a few of the bare terminal branches putting out weak sprouts.

Gegen I. - mostly dead or almost so.

On other islets, normal so far as observed.

Cocos nucifera L.

Uterik I. - normal.

Rongelap I. - normal.

Eniaetok I. - normal.

Kabelle I. - very yellow.

Eniwetak I. - no record of condition.

Gegen I. - some trees dead.

Guettarda speciosa L.

Gegen I. - dead at tips in open scrub; in forest largely dead or severely dying back from tips.

On other islands, apparently normal so far as observed.

Fleurya ruderalis (Forst. f.) Gaud.

Gegen I. - almost dead.

On other islands, apparently normal so far as observed.

Lepturus repens (Forst. f.) R. Br.

Gegen I. - common but completely dead except for a few tiny seedling tufts on beach ridges.

Elsewhere apparently normal so far as observed.

Boerhavia diffusa L., B. tetrandra Forst. f., Achyranthes canescens R. Br., Pandanus tectorius Park., Portulaca lutea Sol., Cassytha filiformis L., Ipomoea tuba (Schlecht.) Don, Tacca leontopetaloides (L.) O. Kize., and Terminalia samoensis Rech. all in poor condition on Gegen I. but nature of damage not recorded. All apparently normal elsewhere so far as observed.

2. Islets visited, in decreasing order of fallout intensity, with plants in which abnormal appearances were observed.

Gegen I.

Achyranthes canescens

Boerhavia diffusa

Boerhavia tetrandra

Cocos nucifera

Cordia subcordata

Fleurya ruderalis

Guettarda speciosa

Lepturus repens

Pandanus tectorius
Pisonia grandis
Portulaca lutea
Suriana maritima
Terminalia samoensis

Kabelle I.

Suriana maritima
Cocos nucifera
Pisonia grandis

Eniaetok I.

Suriana maritima

Eniwetak I.

Cordia subcordata
Pisonia grandis

Sifo I.

Pisonia grandis (only slightly defoliated, probably
normal)
Suriana maritima

Rongelap I.

No species noticed in abnormal condition, but this was
first islet visited and perhaps damage was unnoticed
as attention had not been directed toward it.

Utirik Islet

Suriana maritima (not strongly damaged)

These data are inadequate and are therefore only suggestive. It is by no means claimed that there is any causal connection between fallout and the phenomena observed. However, the clear observation that the poor condition of the vegetation was more intense on the islets where the fallout was more concentrated suggests a relationship. This seems to be of sufficient interest to warrant a careful study. Such a study should determine, first, whether these effects are still observable, and, if so, what the actual nature of the damage is, whether there are significant concentrations of radioactive substances in the tissues, whether there are any notable abnormalities in recovered plants, and whether any young seedlings show abnormalities.

For quick reference all records of plants from the three atolls most seriously affected by the 1954 fallout (except Bikini itself), Rongelap, Rongerik, and Ailinginae, as well as all available records of Marshall Island plants affected or putatively affected by fallout

or other radioactivity have been assembled in the following table. Records indicated by T and by Fc are substantiated by specimens deposited in the U. S. National Herbarium. Many additional species were seen on the NRDL survey but not collected because of lack of time and on the assumption that the species would have been picked up by Taylor at least on the same atoll. This did not always turn out to be the case, but the Taylor and Fosberg collections complement each other fairly well. Important extensions of distribution are reported in a separate paper (see Atoll Res. Bull. no. 68) with citation of specimens.

Legend of symbols used in the table:

Habit of plant:

- h -- herb
- v -- creeper or vine
- s -- shrub
- t -- tree

Abnormalities or reported effects of radioactivity:

- Sp -- St. John, 1950, report of persisting (physiological?) effects.
- Sm -- St. John, 1950, report of mutation.
- Bp -- Biddulph, 1950, report of physiological effects.
- * -- abnormality recorded by Fosberg, 1956.
- U -- abnormality recorded by Fosberg from Utirik, 1956.
- R -- abnormality observed by Sam Rainey on Bikini, 1956.

Miscellaneous data on flora and collections:

- T -- Occurrence reported by Taylor, 1950.
- F -- Occurrence recorded by Fosberg, 1956.
- c -- Herbarium collection by Fosberg, 1956.
- n -- Material collected by Fosberg for radioanalysis at NRDL, 1956.
- e -- Material collected by Evan C. Evans, III, for radioanalysis at NRDL, 1956.

Name of Plant	Rongelap Atoll						Rongerik Atoll	Ailinginae Atoll
	habit of growth	abnormalities or rad. effects	Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.		
<i>Polypodium scolopendria</i>	h						Eniwetak I.	Safo I.
<i>Pandanus tectorius</i>	t	*	Fec*	Fe	Fec	T Fec	Fec	Fc
<i>Chloris inflata</i>	h	Sp				T	Fc	Fec
<i>Eragrostis amabilis</i>	h							
<i>Digitaria pruriens</i> var. <i>microbachne</i>	h				Fnc	T Fnc		Fnc
<i>Lepturus repens</i> var. <i>septentrionalis</i>	h	*	Fn*	Fnc	T Fnc	T Fnc	Fn	Fnc
<i>Eleusine indica</i>	h					T		
<i>Cenchrus echinata</i>	h	SpSm				T		
<i>Thuarea involuta</i>	h				T	Fnc	Fnc	Fnc
<i>Fimbristylis cymosa</i>	h				T	T		
<i>Cocos nucifera</i>	t	Bp*	Fe*	F	Fe	T Fe	Fe	Fe
<i>Crinum asiaticum</i>	h				T	T Fc		

Name of Plant	Rongelap Atoll						Rongerik Atoll	Ailinginae Atoll
	habit of growth	abnormalities or rad. effects	Gegen I.	Kabelle I.	Enlaketok I.	Rongelap I.	Other	Enlaketak I.
<i>Tacca leontopetaloides</i>	h		Fe*	Fe	T Fe	T Fe	T	Fe
<i>Artocarpus altilis</i>	t					Fe		
<i>Fleurya ruderalis</i>	h	Sm*	Fe*	Fe				Fe
<i>Achyranthes canescens</i>	h	*	Fe*					
<i>Boerhavia diffusa</i>	v	Sm*	Fnc*	Fe			T Fe	
<i>Boerhavia tetrandra</i>	v	*	Fnc*	Fnc		Fnc	Fnc	Fnc
<i>Pisonia grandis</i>	t	*	Fnc*	Fnc*	T Fnc	Fnc	Fnc*	Fnc*
<i>Portulaca lutea</i>	h	*	Fnc*	Fnc	T Fnc		Fe	Fnc
<i>Portulaca oleracea</i>	h	SpSmBp						
<i>Portulaca samoensis</i>	h					Fnc	T	
<i>Cassytha filiformis</i>	v	*	F*		T	F		Fe
<i>Caesalpinia</i> sp.	s							
<i>Canavalia microcarpa</i>	v				T	T		

Stifo I.

Name of Plant	Rongelap Atoll						habit of growth	abnormalities or rad. effects	Rongerik Atoll			Ailinginae Atoll
	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Eniwetak I.	Other			Eniwetak I.	Other	Sifo I.	
Suriana maritima	F*	T F*					s	RU*		T	Fc*	
Soulamea amara							t		Fc			
Allophylus timorensis							s				Fc	
Triumfetta procumbens	F	T	F				v			T	Fc	
Sida fallax	F	T	T F				s					
Calophyllum inophyllum							t					
Carica papaya			T Fc				t					
Cucurbita maxima			Fec				v					
Pemphis acidula							ts					
Bruguiera conjugata							t					
Terminalia samoensis							ts					Fc
Ochrosia oppositifolia							t					
Ipomoea pes-caprae							v	Sm				

Name of Plant	Rongelap Atoll						Rongerik Atoll	Ailinginae Atoll
	habit of growth	abnormalities or rad. effects	Gegen I.	Kabelle I.	Eniaetok I.	Rongelap I.	Other	Eniwetak I.
<i>Ipomoea tuba</i>	v	SmBp*	F*		T	Fe	Other	Fe
<i>Cordia subcordata</i>	t	*	F*		F			T Fc*
<i>Tournefortia argentea</i>	t		Fe	Fe	T Fe	Fe	T	Fec
<i>Clerodendrum inerme</i>	s				T	T F	T	Fc
<i>Pseuderanthemum car-ruthersii</i>	s				T	T		
<i>Guettarda speciosa</i>		Sm*	Fn*	Fn	T Fn	Fnc	T	Fnc
<i>Morinda citrifolia</i>		Sm			T Fe	Fe	T	Fec
<i>Scaevola sericea</i>		Sm	Fe	Fe	Fe	Fe	T	Fec
<i>Wedelia biflora</i>	v					T		Fc

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Health and sanitation survey of Arno Atoll

by

John D. Milhurn

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Health and Sanitation Survey of Arno Atoll, 1950^{1/}

by

John D. Milhurn^{2/}, ^{3/}

In the late 1940's, the United States Navy assigned the U.S.S. WHIDBEY (AG-141) to conduct health and sanitation surveys of the Trust Territory Islands. The WHIDBEY arrived at Arno Island, Arno Atoll, on April 30, 1950 for this survey. The following summary has been abstracted from their report:

Arno Atoll has the largest land area of any atoll in the Ratak chain of the Marshall Islands. It is composed of 25 to 30 low islands and coral reefs which seem to be the remains of a crater rim. These form a circular barrier protecting a large lagoon. Many of the islands of the Atoll are densely covered with coconut palms and pandanus trees. A coral reef which is difficult and at times hazardous to navigation protects the entrance to the lagoon.

Two major villages exert their separate spheres of influence. Arno village on Arno Atoll influences the people of the surrounding smaller islands. Ine village, on Ine Island, a long narrow coral island in juxtaposition to Arno, is more important, being the seat of the Island Trading Company for the Atoll. Natives living on smaller islands of the Atoll while making copra are listed for census purposes as belonging to either Arno or Ine village. On festive occasions such as Christmas and the Fourth of July, which the natives have adopted, the entire population of the Atoll gathers on Ine for feasting, celebration, and even baseball at the Ine ballpark.

According to the Civil Administration Government at Majuro, the 1946 census of Arno Island was 256 and of Ine Island 302. The U.S.S. WHIDBEY located only 194 persons on Arno and 206 on Ine, including three visitors from Kaven (Maloelap Atoll) who had been examined on the ship in 1948. A determined effort was made to examine every native. One of the medical officers of the WHIDBEY visited each house or hut to induce the occupants to visit the other medical officer at the town house in the municipal square. It was the opinion of these medical officers that every native in both villages and their environs was processed and examined. Time and the difficulty of locating those natives on the sparsely settled, small uncharted islands made efforts to examine the remaining population impracticable.

1. Abstracted from original report by members of the Preventive Medicine Division, Bureau of Medicine and Surgery, Department of the Navy, Washington 25, D. C.
2. Member, U.S.S. WHIDBEY (AG-141) Survey Team.
3. Opinions expressed herein are those of the authors and are not to be construed as official or as representing the opinions of the U. S. Navy or naval service at large.

It was noted that the Marshallese are a very itinerant people who have little hesitation in undertaking sea voyages in an outrigger canoe. One of the natives not examined was a Chief Magistrate said to be visiting Majuro. This suggested to the WHIDBEY group the importance of planning surveys for simultaneous coverage of whole island groups rather than individual islands. Despite the failure to locate and examine a portion of the Atoll population, the WHIDBEY group were of the opinion that a representative sample had been examined.

"The Marshallese on the Arno Atoll welcomed the WHIDBEY with curiosity, delight, grace and hospitality. They showered us with their home-made leis, and gave freely of their limes, papayas, bananas, coconuts and pandanus. At no time were any of the beach party thirsty, being lavishly supplied with coconut milk. For the people, especially the young and the ancient, the ride in our dukw and the visit to the ship were holiday treats. School was even called off (and this probably occurs at the slightest pretext). The authorities there freely cooperated and showed our sanitation officer everything, hiding nothing from view. Even the dogs were startled at the sight of the monstrous dukw rolling along the primitive, Japanese constructed island roads.

"The young men demonstrated their native game of jog jog (phonetic spelling). They played this game, which is reserved for the men only, with great frivolity and mirth. The game is similar to our red rover and chug-a-lug and is played with a square ball made from pandanus fibres. The men stand in a circle and the man out stands in center. One man begins by throwing the ball in the air and kicking it with the sole of his everted and flexed right or left leg. As the ball approaches another man, regardless of his position in the circle, he must kick it similarly and so on the game progresses until one man misses when they start over. At the time the ball is first kicked a single clap of the hands in unison by all starts. After the third kick the clapping is coupled. Evidently the center man merely has the duty of keeping the ball in the air should it come to him for they never assumed or changed places in the circle. The problem of scoring is a mystery.

"Arno Island is about 2 1/2 miles long and 1/2 mile wide possessing in addition to its coconut and pandanus trees, a thick underbrush of vines. There are about 3-5 acres of arable land but cultivation of cleared areas would be difficult. Ine is a long narrow island (13 miles long and 1/4 mile wide) with a topography similar to that of Arno Island.

"The government of each village is democratic in form. The Chief Magistrate is elected for an indefinite period. In the Marshall Islands the Chief Magistrate's influence over his people is directly proportional to the extent of their Americanization, being less where American influence is greatest. There are also a registrar and a scribe of Arno Atoll, who reside on Ine. Whether or not each native understood the humanitarian instincts propelling this survey and just what he expected as a result of the survey is unknown. They submitted to processing and examination without question.

"The native economy of Arno as elsewhere in the Marshalls depends directly on the sale of copra and handicraft. In dollars and cents,

there are no apparent millionaires in Arno, but in spirit and health there are many, and perhaps proportionately speaking, many more than in the U. S. A. Their diet consists of home grown coconuts, breadfruit, pandanus, bananas, papayas, fish and pork and is varied slightly with imported rice, sugar, flour and canned corned beef, milk and beef.

"There is one school on Arno Island with 30 students (6 - 14 years old) and a missionary school and an elementary school on Ine with 47 pupils (7 - 20 years old) pursuing general studies with some sanitation principles being added to the curriculum. All natives speak and write Marshallese but only 8 adults understand English. All the natives were Protestant, holding Sunday services with a native minister from Ine. The Congregational Church, U. S. A. has established a mission school at Kusaie in E. Carolines where the native ministers (usually the Magistrates) are trained. The Bible has also been translated into Marshallese along with many Protestant Hymns. Not infrequently, when you offer a cigarette to the Magistrate, the interpreter will say, 'He no smoke. He Missionary!'

"Medical facilities on Arno Atoll are scarce. A new thatched dispensary is being built in Arno village. Obstetrical cases are delivered at home with little regard to asepsis by a midwife or the native practitioner (who although trained at Majuro is little more than a medical aid). The parents and immediate families care for the young, the ancient and insane. Tuberculous and leprous cases are left free to roam the Atoll, when found. There is no understanding of the principles of contagion and no facilities for isolation. The treatment of yaws (oftentimes being misdiagnosed as yaws and actually impetigo or pyoderma), of skin diseases and minor surgery conditions is left to the practitioner. Most of the people have been vaccinated for smallpox. Other immunization procedures are not recorded. No epidemics or water-borne or milk-borne diseases have been mentioned.

"The water supply is derived from rain water and although adequate is considered contaminated. One 20-ton concrete cistern built by Germans was found on Ine. Half of the cisterns are uncovered and contain trash. All the wells are uncovered and do not exclude surface drainage. Some of the water is boiled. Each village either defecates and urinates in the available unscreened latrines or on the beaches or in the interior. Living areas are dirty and unpoliced. Garbage is disposed of, however, in sanitary fills or by burning. Housing is of thatch and although not too clean, is adequate.

"Rodents and flies are numerous. Some culicine mosquitoes were noted on Ine. There are no control measures for rodents. Flytraps and sanitary garbage fills are fly control measures. There are no known plans to cope with disasters or epidemics. DDT is in use to control mosquitoes on Ine.

"Vital statistics (births and deaths) are filed in certificate form by the practitioner at Majuro. The scribe keeps record on Ine of marriages, divorces; court records, births and deaths for Arno villages.

"For the year 1949, the death rate at both Arno and Ine was 45/ thousand, considerably higher than the all-time high in U. S. A. of 23.0

in the last two decades. The leading cause of death at Arno is reported as tuberculosis but this statement may be challenged due to the poor vital statistical record and lack of knowledge of different diagnoses by practitioner.

"The native population of Arno definitely surprised the survey team for they presented a summary picture of excellent health. While their health facilities are relatively primitive, environment and time seem to be wedded in a union to protect these people from the vicissitudes of our modern civilization. The lack of time to complete thoroughly the preponderantly detailed survey examination of these people (3 days were allotted per village) and the language difficulties do not insure accurate statistics. The figures in this report represent, however, the best efforts of the survey to formulate an accurate picture of the health and sanitation of this island."

Some of the results of the Health Survey follow:

Coccidioidomycosis and Histoplasmosis

Approximately 96 per cent of the natives were skin-tested with these two antigens, children under 1 year of age being excluded. The test consisted of intracutaneous injection of 0.1 cc of a 1:500 dilution of Histoplasmin and 1:100 Coccidioidin. Results were read at 48 hours and no positive reactors were found. It was noted that the antigens had been in refrigerator storage on the ship for five months prior to use and might have deteriorated. Judgment of the team, however, was that these two mycoses were either absent or rarely occurred since chest roentgenograms did not reveal abnormalities suggestive of old infections.

Tuberculosis

Thirty-five per cent of the natives examined had positive skin reactions to 0.0001 mgm of PPD (Purified Protein Derivative) intracutaneously. One-half of positive reactions were in persons age 40 or over.

All natives were screened with 35 mm. photofluorographs. Those with suspicious findings were further evaluated with 14 x 17 inch roentgenograms. Three cases of active tuberculosis, two men and one woman, were found. All were over age 50. Three additional cases were strongly suspicious, one a child less than 10 years of age, and two women over age 40. All six had 2+ to 4+ dermal reactions to PPD.

It thus appeared that about 1.5 per cent of natives had proven or suspicious tuberculosis. No case of extrapulmonary tuberculosis was found.

The survey group commented on the apparent lesser incidence of tuberculosis at this Atoll than in other parts of the Trust Territory and the discrepancy between their findings and the official report of deaths due to tuberculosis for the past calendar year.

Yaws

Serological tests were completed on 149 residents of Arno (76.8 per cent) and 143 of Ine Island (70 per cent). Positive results were obtained in 103 and 94 sera (or 66.2 per cent and 69 per cent), respectively.

Twenty (20) cases considered to represent primary yaws on the basis of a peculiar raspberry-like lesion of the skin were found. Scrapings from these lesions were negative on darkfield examination. Six of the 20 had positive Kahn tests. These lesions appeared to be a latent phase of the primary stage for they were crusted, and the positive serologies explainable because of the lateness.

Seventy-nine (79) others were considered to have secondary yaws on the basis of peculiar annular, mottled, prickeled, indented scars of the skin. Such scars had to be differentiated from those due to burns resulting from the native practice of night fishing by torch light. Seventy-four (74) of the 79 had positive Kahns, the remaining 5 being too young for an adequate blood sample.

The remaining 116 natives with positive serologies showed no evidence of primary, secondary, or tertiary yaws. Neither was there any history or other evidence of syphilis, infectious mononucleosis, influenza, yellow fever, or malaria. These cases were, therefore, considered to have inactive yaws with a negative history.

Two women over age 50 had bilateral swelling about the bridge of the nose and gave questionable histories of yaws at an early age. Both had negative serologies. These were suggestive of N'Gondou, supposedly a tertiary manifestation of yaws.

Four men and women over age 50 had positive serology and a dilated tortuous aorta. All had either an accentuated aortic second sound or a low blowing systolic murmur at the base of the heart. None had diastolic murmurs or wide pulse pressures. None had a history suggestive of syphilis. These may have represented arteriosclerotic heart disease or syphilitic aortitis. Because of the endemicity of yaws and infrequency of syphilis, however, the Survey Team raised the possible connection with tertiary yaws since similar findings had been made on other islands.

One case with bone involvement considered to be tertiary yaws was found. No cases with juxta-articular nodes or gangosa were encountered.

The overall incidence of active and inactive yaws among natives was estimated to be 53 per cent.

Syphilis

The Germans and Japanese had reported the prevalence of syphilis in the Marshall Islands. The survey found four cases of clinically suspicious primary lesions, all of which had negative darkfields. One other case was thought to have congenital syphilis on the basis of history.

The diagnostic difficulties between yaws and syphilis were recognized. The possibility existed that some cases considered to have yaws might be syphilis. Further diagnostic difficulties in regard to active lesions were posed by skin lesions of pyogenic or other origin.

Leprosy

No cases were found despite a careful examination. A number of natives were found with lesions on the face or trunk which might have been suspicious but lacked any sensory nerve changes. Acid-fast stains on scrapings from a number of these lesions did not reveal M. leprae. Five elderly people had ulnar nerve thickening but no sensory changes. All gave a history of phalangeal fractures or traumatic laceration of the palms.

Parasitic Infestation

Stool examinations were made on 253 natives. Since these were not fresh, accurate data on the prevalence of Endamoeba histolytica or E. coli could not be obtained. Sugar flotation and direct smear examinations were made in each case. Intestinal parasites were identified in 53 or 18.2 per cent of specimens, these consisting of hookworm, Trichuris trichiura, and Giardia lamblia. Infestation in specimens from people over age 15 was twice that of specimens from people under this age. Hookworm was found in 7 per cent of specimens from Arno and two per cent from Ine. The respective percentages for T. trichiura was 5 and 9 and for Giardia lamblia 1.2 and 7.2.

Ascaris lumbricoides was not found.

Mycosis

Approximately 26 per cent had clinical evidences of mycotic infections, mostly, Tinea versicolor. The incidence was five times greater in adults than in children under age 15 and ten times greater in males than in females. Two cases of Tinea imbricata were seen on Ine.

Other

Approximately 4 per cent appeared malnourished and some, in addition, to be dehydrated. All were over age 40.

About 3 per cent were clinically obese, apparently on the basis of simple caloric excess, and all of these were between age 20 and 40.

One suspicious case of ichthyosis and one of rickets were seen but in general there was no evidence of vitamin deficiency.

Twelve cases (3 per cent) had clinical evidence suggestive of iron deficiency anemia. Three were pregnant women, the other 9 children under age 10. Two of the 9 children had positive stools for hookworm, one for Trichuris trichiura and one for Giardia lamblia.

Several suspicious cases of venereal disease were seen but only one proven, this being a case of gonorrhea.

Several benign neoplasms, including two cases each of pigmented and nonpigmented nevi were found but no malignant tumors. Leukoplakia buccalis was found in 14 natives, this lower incidence as compared to some other islands apparently being related to the fact that betel nut chewing is not a habit.

Two cases of Mongoloid idiocy were discovered on Arno in brothers aged 8 and 24 years. No information could be obtained about the parents or other relatives.

Eye, ear, nose and throat abnormalities were common. Pterygia were found in 71 persons (probably because of conjunctival irritation from coral) and chronic tonsillitis in 130 natives.

Three cases of bronchial asthma constituted the only allergic disorders encountered.

Nine natives were suspected of having hypertension on the basis of blood pressures above the level of 140/90 on the single examination. No evidence of cerebral, cardiac, or renal abnormality was noted in conjunction with these elevations.

Eleven had external hemorrhoids and there were 7 natives with indirect inguinal hernia, two with umbilical hernias, and two with pilonidal cysts. Seven women had uncomplicated pregnancies. One woman age 60, a nullipara, had a complete uterine prolapse.

Three cases with talipes equinovarus and one with polydactylitis constituted the major congenital orthopedic abnormalities.

Summary

The inhabitants of Arno Atoll appeared to be generally in excellent health and a state of good nutrition. Tuberculosis appeared to be the single major disease threatening health.

ATOLL RESEARCH BULLETIN

No. 63

Report on a visit to the Chesterfield Islands, September 1957

by

F. Cohic

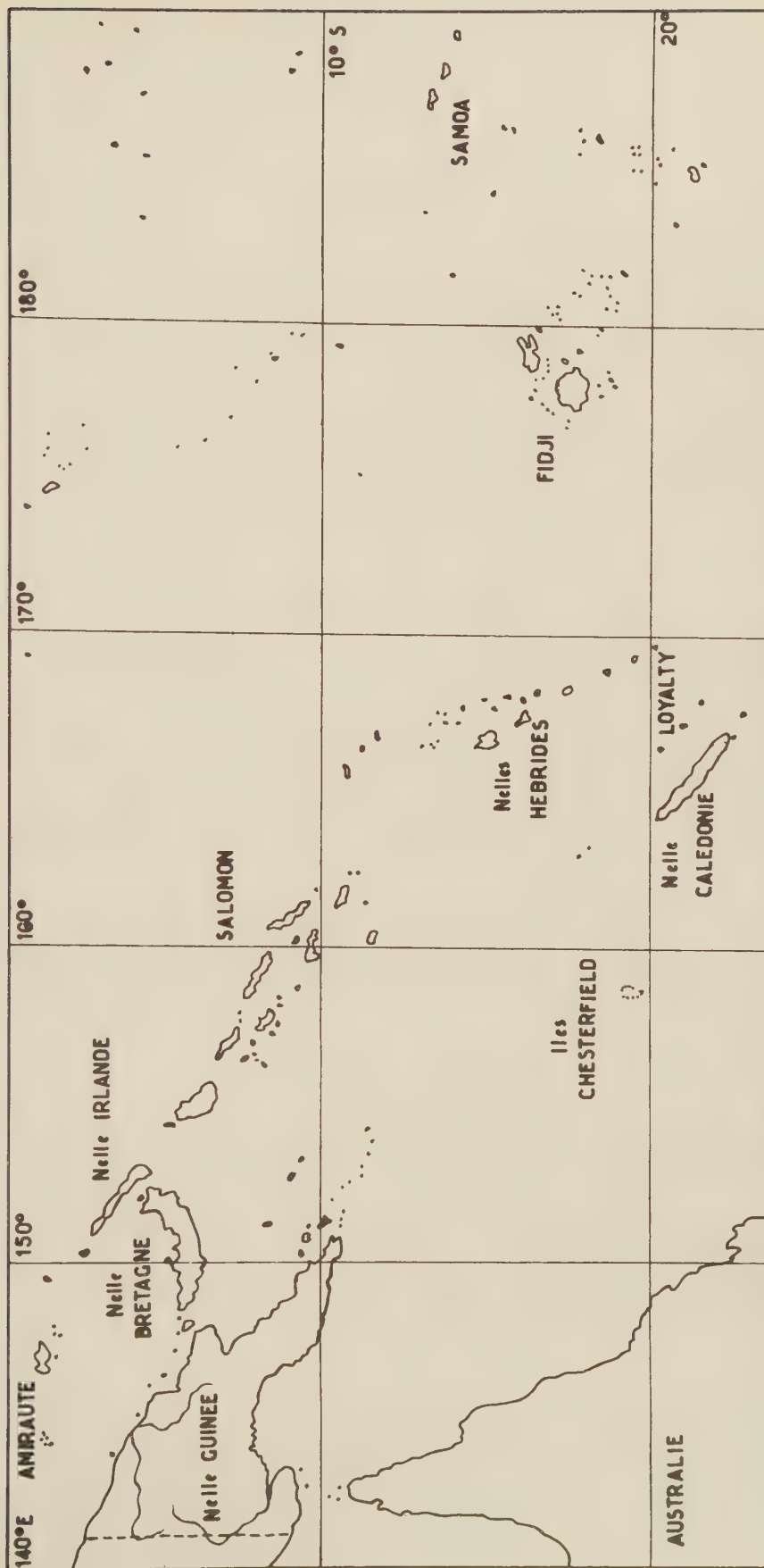
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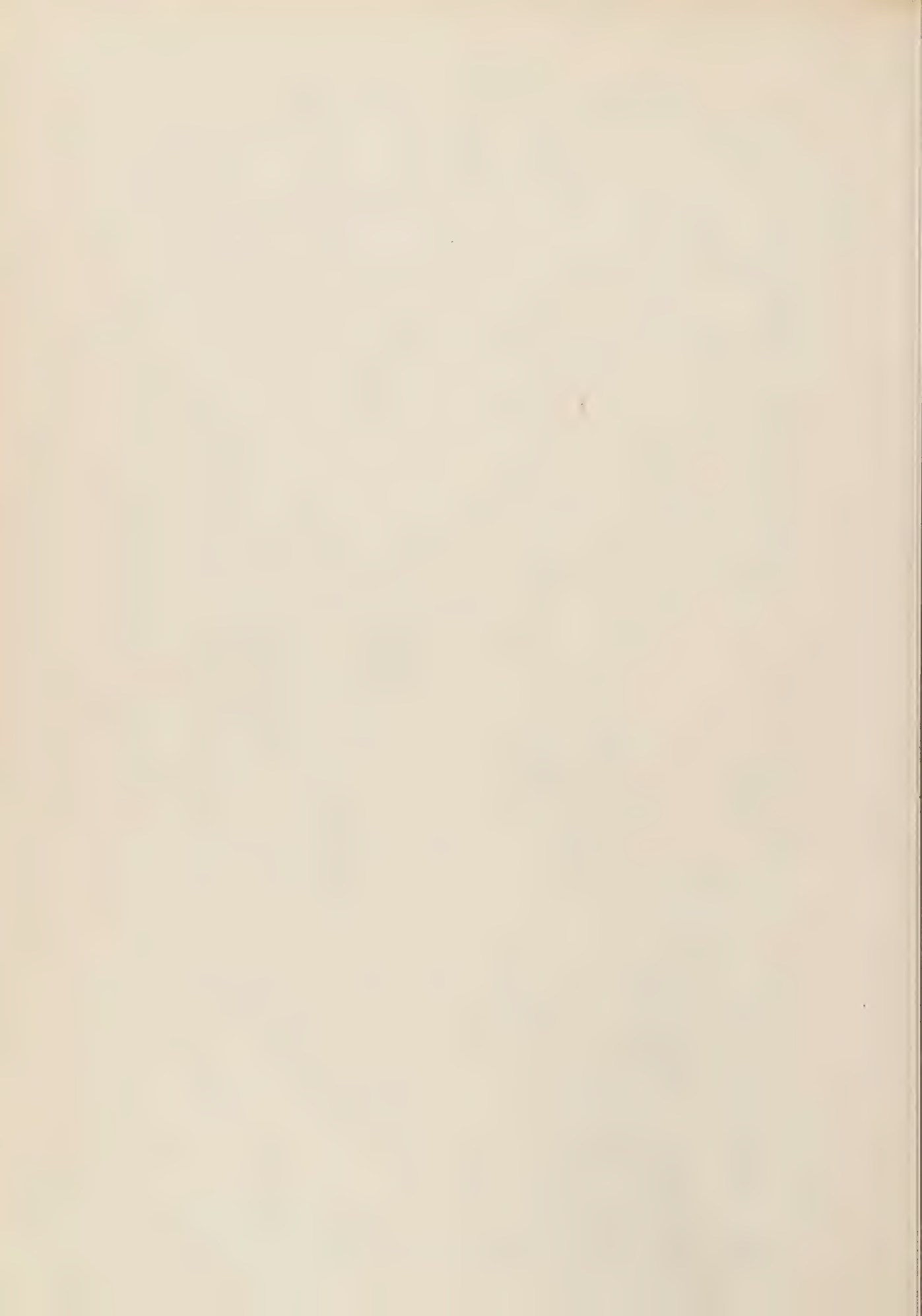
National Academy of Sciences--National Research Council

Washington, D. C.

May 15, 1959



Southwest Pacific area showing
Chesterfield Islands



Report on a visit to the Chesterfield Islands, September 1957^{1/}

by
F. Cohic

Introduction

The most westerly French possessions in the South Pacific, the Chesterfield Islands, are of interest to zoo- and phyto-geography. They are at the junction of several biogeographic regions, Australian, New Caledonian and New-Hebridean. There was a complete lack of information on these islands, so it was obvious that a visit would be fruitful. The visit, unfortunately very brief, only 4 hours, was made possible by the invaluable cooperation of the French Navy. We wish to express our gratitude for the opportunity to the authorities in charge, particularly to Admiral de Toulouse-Lautrec, and to thank the officers and crew of the sloop Francis Garnier, who were very helpful to us.

Location and history

The Chesterfield group is located about 500 km. north-west of New Caledonia, in the middle of the Coral Sea, and stretches between 158 and 159 degrees of Longitude East, and 19 and 20 degrees Latitude South. They include 11 islets, the main ones being the Chesterfield islets, Longue Island, and Avon, Renard and Bompton islets. Their total area is less than 1000 hectares. This coral group, halfway between Australia and New Caledonia, is completely uninhabited and isolated from shipping routes, and avoided as a danger to navigation.

The Chesterfield Islands have been a French possession since 1876, and have only been rarely visited by whalers and warships. The last French vessel was the Dumont d'Urville which surveyed the island and prepared a map in 1939.

Longue Island

This is the principal islet on the V-shaped coral reef, and was the only one visited. It is a narrow tongue of sand, approximately 1800 m. long and 130 m. wide, and only 7 or 8 m. above sea level.

It seems to be formed of a slightly raised platform, which has later been subject to wind erosion. The various borings made down to about 3.5 m. have revealed a regular stratification of darker guano-bearing sand

^{1/}This report is an abstract translation by M.-H. Sachet of a French paper, issued here by permission of the author. The original, entitled Rapport sur une mission effectuée aux Iles Chesterfield en Septembre 1957, 20 pp., Oct. 1957, was issued by the Institut Français d'Océanie, Noumea, New Caledonia, where the author is an entomologist.

layers alternating with lighter layers apparently free of guano, which seems to indicate that the surface has been repeatedly buried under new deposits probably by typhoons. No boulders or large size coral debris were observed. Along the shore can be seen some slabs of sandstone^{1/} similar to those seen in the Loyalty Islands, a fact which may support the idea that the island is raised. From the point of view of pedology, the soil is made up of calcareous sands of a rather coarse texture, with a thin brownish humus-bearing layer, often buried under sand. The island has no fresh water.

Vegetation

Several plant associations can be recognized:

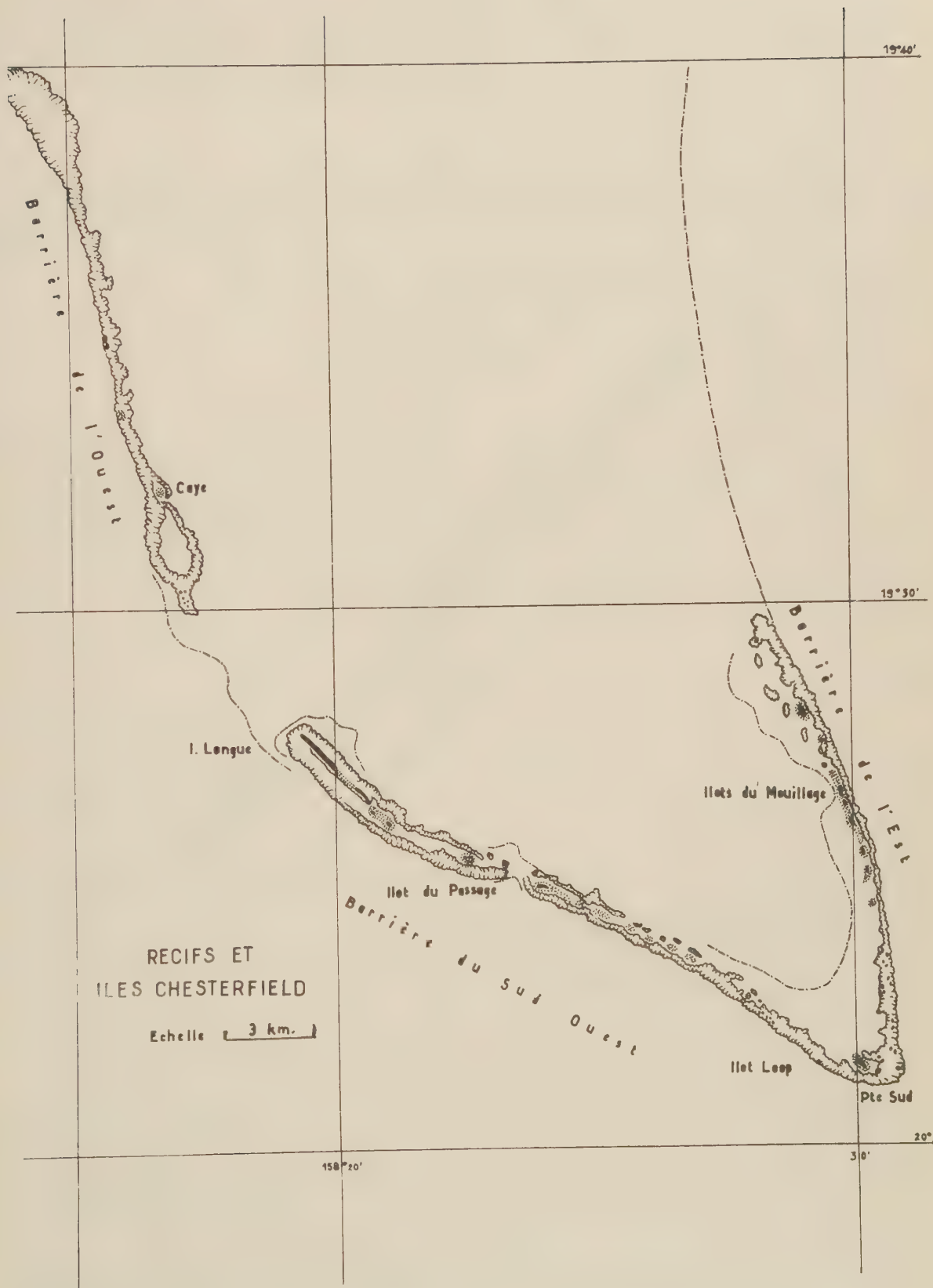
a.) On the sandy, very sunny east slope Triumfetta procumbens forms large patches. Often associated with it, and even mixed with it Boerhavia repens (= Boerhavia diffusa) forms similar patches. Other plants found in this vegetation type are rounded patches of Coronopus integrifolius, a few clumps of Portulaca lutea and many scattered plants of Didiscus sp. (Umbelliferae). Cassytha filiformis is also associated with this vegetation type, covering plants of Triumfetta and Boerhavia with its string-like stems.

b.) On the east edge of the plateau the plants listed above are found again, but in smaller numbers. The low vegetation is made up mostly of grasses with Lepturus repens and Stenotaphrum sp. as dominants, forming a dense harsh turf, more or less continuous. There are only some clumps of woody plants, mostly in pure stands. The species are Sophora tomentosa, Scaevola sericea and Colubrina asiatica.

The shrubs, particularly Sophora and Scaevola, are the principal nesting sites of frigate birds and certain boobies and thus determine the areas where guano is deposited. This vegetation is mostly dead with skeleton-like branches carrying the few twigs forming each of the numerous nests. The accumulated droppings burn the leaves and branches and perhaps the excess of toxic salts in the soil disturbs the physiology of the plants which are slowly disappearing. By contrast some isolated clumps, or some shrubs too low for the gregarious birds to nest on are remarkably luxuriant.

c.) On the plateau, the vegetation is mostly made up of grasses of at least 5 species among which are Lepturus repens, Stenotaphrum sp., and Cynodon dactylon. The Lepturus cover is very hummocky in the central part, with deep hollows between the rounded clumps. Cynodon, or Bermuda grass, is very local and forms patches of very fine turf. Numerous clumps of Achyranthes aspera are scattered here and there, with occasional plants of a yellow-flowered Malvaceae, Abutilon molle, and of tobacco, Nicotiana tabacum. On the west part of the plateau, the beach morning-glory, Ipomoea pes-caprae, forms a few patches.

^{1/}The photographs kindly sent by the author show this sandstone is typical beach rock. Ed.



19° 52'



53'

ILES CHESTERFIELD
MOUILLAGE DE L'ILE LONGUE
Echelle [400m.]

19°

150° 20'

The island also carries a dozen coconut palms which are growing rather poorly because of the violent winds, but particularly because of the bird droppings, which burn the fronds, and perhaps because of an excess of phosphate and nitrates in the soil.

Flora

The flora of Longue Island is remarkably poor. All the species present are strand plants of wide Indo-Pacific distribution, which are also found on the coral islets around New Caledonia.

List of plants^{1/} of Longue Island

ANGIOSPERMAE

Monocotyledonae

Gramineae

Cynodon dactylon (L.) Persoon
Lepturus repens (Forst.) R. Br.
Stenotaphrum sp.
Spinifex littoreus
Thuarea involuta (Forst.) R. Br.

Palmae

Cocos nucifera L.

Dicotyledonae

Amaranthaceae

Achyranthes aspera L.

Nyctaginaceae

Boerhavia repens L.

Portulacaceae

Portulaca lutea Forst.

Lauraceae

Cassytha filiformis L.

Cruciferae

Coronopus integrifolius Spreng.

Leguminosae

Sophora tomentosa L.

Zygophyllaceae

Tribulus cistoides L.

^{1/} Nomenclature and order adjusted somewhat from that in original French version. Ed.

Rhamnaceae

Colubrina asiatica (L.) Brongn.

Tiliaceae

Triumfetta procumbens Forst.

Malvaceae

Abutilon molle Sweet

Umbelliferae

Didiscus sp. (probably D. cussonii Montronzier)

Convolvulaceae

Ipomoea pes-caprae (L.) Roth

Solanaceae

Nicotiana tabacum L.

Goodeniaceae

Scaevola sericea Vahl

This flora of 20 species in 20 genera and 16 families is very poor. All the species are characteristic of coral strands; all are higher plants, no fern, moss or lichen were found. They are well adapted to the habitat and resistant to salt. Many have extensive root systems, and fleshy, or very hairy leaves. Most of them have fruits or seeds adapted to dissemination by ocean currents (corky fruits, long viability) or by sea birds (sticky or spiny fruits). Because of the extreme isolation of these islands, few species have been able to reach them and establish themselves.

During our short visit to Longue Island, a few plants were introduced by the Service d'Agriculture of New Caledonia. These were: coconuts, Araucaria columnaris (Forst.) Hook., Sesbania grandiflora Pers. and Leucaena glauca (L.) Benth.

Terrestrial fauna

The land fauna of Longue Island is very small. There are no mammals, amphibians or land reptiles. The few groups represented are birds, turtles - which come on land to lay eggs, sea snakes, a few Arachnida and insects.

A. AVES

The Chesterfield Islands, and particularly Longue Island, are an important roosting and nesting site for sea birds, which explains the formation of guano deposits. At the time of our visit the principal families represented were Sulidae and Fregatidae.

Sulidae

Sula sula rubripes Gould. The red-footed boobies nest mostly in the shrubby vegetation of Sophora tomentosa and Scaevola sericea. The nests contain only one egg, of a greenish white color and covered with a chalky deposit.

Sula dactylatra personata Gould. The blue-faced boobies nest directly on the ground, without any twigs or nesting material, among the clumps of Triumfetta, Boerhavia and Lepturus. The nests contain two eggs but usually only one young.

Sula leucogaster Boddaert. The brown boobies also nest on the ground but with a rudimentary nest of twigs usually protected from the sun. The females lay two or three eggs, but usually only one young grows up.

Fregatidae

Fregata ariel Gray. The lesser frigate bird characterized by the two white lateral markings of the male is the most abundant. The nest is usually perched on Sophora tomentosa shrubs and built of twigs more or less cemented by a hard substance. It contains only one chalky white egg.

Fregata minor palmerstoni. The great frigate bird appears to prefer Scaevola sericea bushes, but sometimes also nests on grass clumps in the open.

Other seabirds of the family Laridae (Larinae and Sterninae) were seen nesting on these low islands, but could not be identified.

B. CRUSTACEA

1. Isopoda-Oniscoidea

At least two species are present and especially abundant under coral boulders and plant debris.

2. Decapoda-Anomura

Coenobitidae

Coenobita perlata M.-E. This hermit crab is one of the most obvious elements of the fauna of the Chesterfield Islands. This species of the tropical Indo-Pacific area is adapted perfectly well to terrestrial life and practically never goes to the sea except for egg laying. These animals are of a beautiful red color, with little yellow tubercles bearing a black spine, and live on the part of the beaches above the reach of the highest tides, and also quite far in the interior, as we had already seen in Makatea.

In the Chesterfield Islands, the hermit crabs are exceedingly numerous and can be found during the day under coral boulders, under drift wood (pieces of canoes, bamboos, tree-ferns) and plant debris. The specimens observed were all of a large size and lived mostly in shells of Trochus and Turbo. They are mostly scavengers and clean the area of all sorts of material (fish, dead birds, etc.) but also eat the plants, as shown by their droppings which are full of plant cells and chlorophyll. However, while they are able to scale the coconut palms they do not appear to attack them and are not responsible for their poor condition.

C. ARACHNIDA

i. Acarina

a. Sarcoptiformes

Oribatei-Neolioididae

A specimen, probably of the genus Neoliodes was captured in the sand under the nest of the red-footed booby.

Oribatei-Galumnaidae

Eleven specimens of a species in this group, characterized by wing-like lateral appendages were collected in guano-bearing sand in a booby nest.

Acarididae-Analgidae

Sulanyssus caputmedusae Trouessart. This species was kindly identified by Dr. Jean Gaud of the Institut d'Hygiene du Maroc. Specimens were found in the feathers of Sula dactylatra and Sula sula. The females are viviparous, the males apparently are all heteromorphic.

b. Mesostigmata

Gamasina-Laelaptidae

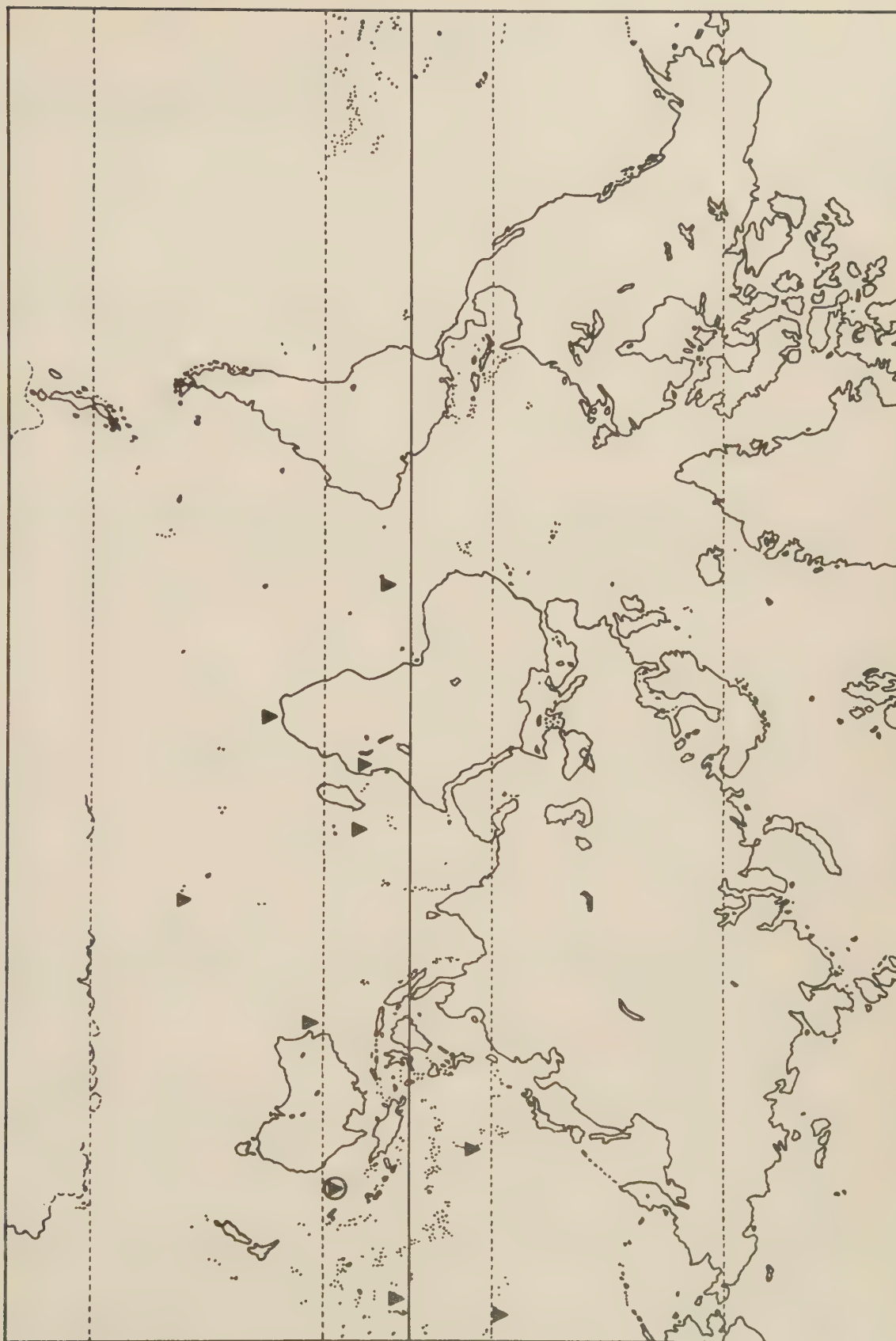
Many specimens were found in the litter of some frigates (Fregata ariel) brought back alive. This is a parasite of mammals, and as these are apparently completely lacking on Chesterfield, the acarids probably were due to accidental contamination aboard ship or in the animal raising laboratory.

c. Ixodidae

Argasidae

Ornithodoros capensis Neumann. This species was kindly determined by Mr. J. Rageau, medical entomologist and veterinarian for the Institut Francais d'Oceanie. A specimen of this tick was captured on Sula dactylatra and several more found later. This species is reported from French Oceania and from this host, for the first time. To our knowledge it had been reported so far from Ascension I. in the Atlantic (Speiser 1909), from penguin nests (Spheniscus demersus) on the guano islands near the Cape (Neumann 1901), from St. Paul I. (New Amsterdam group, Nuttall 1908) and from the west coast of Australia on Eudiptula minor (Taylor and Murray 1946). In the Pacific, the species was known only from Micronesia (Guam, Kohls 1953) and the Hawaiian Islands (French Frigate Shoals, Joyce 1953). It is most likely that this species is very widely distributed and will be found in many islands where seabirds roost. Van Zwaluwenburg (1955) records an exuvium of Ornithodoros sp. from Canton Island; quite possibly it is the same species.

It may be noted that the bite of this tick is particularly painful for man.



▲ : AIRE DE DISTRIBUTION D'ORNITHODOROS CAPENSIS NEUM.

2. Chelonetida

Several specimens belonging in this group were collected from litter under Sula dactylatra.

3. Araneida

a. Sicaroidea

Oonopidae

Scytopes sp. probably S. marmorata L. Koch. Two females were collected. They feed on cicadellids and small orthoptera.

b. Aranoidea

Dionychae Thomisidae?

One specimen was collected on the beach.

Trionychae Agelenidae

One male and two females were found under a coral boulder.

In addition two species of Araneida could not be placed.

D. INSECTA

1. Blattaria

At least two species are present, from the egg cases found under dead wood.

2. Orthoptera

a. Grylloidea

Gryllidae Nemobiinae

One female, completely apterous was caught under a clump of Boerhavia.

b. Tettigonoidea

Tettigoniidae

One female was caught in a sweeping net.

c. Acridoidea

Acrididae

Ten or so specimens caught on Cynodon dactylon and Lepturus repens.

3. Embioptera

Oligotomidae

Oligotoma oceanica Ross. A female specimen found in seabird litter.

4. Mallophaga

1. Amblycera

Menoponidae Menoponinae

Colpocephalum spineum Kellog (det. Mr. J. Rageau) from Fregata ariel.

Myrsidea sp. from Sula dactylatra.

2. Ischnocera

Philippteridae

Pectinopygus (Pectinopygus) sulae (Rudow) on Sula sula rubripes.

5. Homoptera

a. Fulgoroidea

Araeopidae (Delphacidae)

Many specimens were swept from grasses. Sexual dimorphism is strong, the males having the hind wings of an iridescent smokey black and the females transparent. These specimens bring to mind the genus Liburnia.

b. Cicadoidea

Cicadellidae Euscelinae

Orosius sp. Two specimens were caught on grasses.

Cicadellidae Typhlocybinae

About 60 specimens were caught on Boerhavia. The plant is literally infested with this small species and has many discolored yellowish spots.

Cicadellidae Jassinae

Eurinoscopus sp. One specimen.

6. Heteroptera

Gymnocerata

Miridae Capsinae

Four specimens caught by sweeping.

Miridae Cylapinae

Ten specimens caught by sweeping.

Miridae Phyllinae

Campylomma sp. Four specimens caught by sweeping.

Miridae Heterominae

Cyrtorhinus sp.? One specimen caught on Boerhavia. Very likely it is a parasite of the eggs of the Araeopidae.

Lygaeidae Lygaeinae Orsillini

Nysius sp. Numerous specimens caught on Boerhavia.

7. Coleoptera

Only four species were collected.

Histeridae

Four specimens found in the droppings of Coenobita perlata.

Tenebrionidae

Gonocephalum sp. Found under coral boulders and dead wood.

Undetermined Tenebrionidae. Three specimens found in same habitats.

Curculionidae

One specimen found by sweeping.

8. Lepidoptera

Pyralidae Pyraustinae

Hymenia recurvalis (Fabricius). One specimen was caught while flying. The caterpillars most likely live on Achyranthes aspera.

9. Diptera

Hippoboscidae

One specimen was seen flying but could not be caught. It was intensely black with a heavy and noisy flight, and at first sight would seem to belong in the genus Olfersia so common on frigate birds in the Pacific.

Chloropidae

Cadrema sp. About 100 specimens were caught on the guano around birds nests.

Calliphoridae

Lucilia sp. One specimen.

Dorilaidae (formerly Pipunculidae)

Four specimens; probably a parasite of larvae of Araeopidae and Cicadellidae.

Sarcophagidae

Sarcophaga sp. One specimen on a dead Sula sula.

Milichidae

Three specimens, much like Milichiella lacteipennis (Loew).

Lonchaeidae

10. Hymenoptera

Formicidae Formicinae

A few specimens found in guano-bearing sand, under a stone.

Formicidae Pseudomyrmecinae

Numerous colonies found in sand under dead wood and in the bases of palm fronds.

This faunal list does not pretend to be complete, our visit to the island being much too short. However, it is sufficient to show the complete absence of certain important groups, which we particularly searched for, such as Isoptera, Odonata, Culicidae, Tabanidae, Aphidae, Coccidae, Coccinellidae and Vespidae.

It is possible that during the wet season the arthropod fauna of the Chesterfield Islands is richer and more abundant than during our visit in a very dry period, but it probably is not very different from what we observed.

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ATOLL RESEARCH BULLETIN

No. 64

Canton Island, South Pacific
(Resurvey of 1958)

by

Otto Degener and Isa Degener

Issued by

THE PACIFIC SCIENCE BOARD

National Academy of Sciences--National Research Council

Washington, D. C.

May 15, 1959

Canton Island, South Pacific
(Resurvey of 1958)

Otto Degener^{1/}^{by} and Isa Degener^{2/}

The present paper is based on observations made on Canton Island in February 1958, and resulting recommendations. It chiefly supplements observations made by Degener & Gillaspy on this atoll in 1950-1951, and to get a better perspective of the situation the reader is advised first to study Atoll Research Bulletins 41-43 if he has not already done so. The present survey was made through arrangements with Mr. John M. Beardslee, Regional Administrator, Sixth Region, Civil Aeronautics Administration, Honolulu, Hawaii, aided by Canton residents Dr. Owen King and Mr. Earl King.

CLIMATE

A table of meteorological data was published in Bulletin #41, pp. 7-8, taken from the U. S. Weather Bureau's publication, Local Climatological Data, ... Canton Island, South Pacific, for 1954. More recent editions of this Weather Bureau summary, through 1957, are available from the U. S. Superintendent of Documents, Washington 25, D. C. for 15 cents.

SOILS

It is said that Canton was once so covered with guano that its harvest was long a lucrative export during the latter half of the Nineteenth Century. Even though most of the island has been disturbed by bulldozers, certainly some few areas must have escaped their turmoil as well as that made by the earlier shovels of the guano diggers. Yet, in company of the soil expert Dr. Lyle T. Alexander of the Soil Conservation Service, U. S. D. A., the writers could not find a speck of guano in February 1958. Has wetter weather leached guano out of the soil? Or has the coming of man so decimated the bird population that bird droppings now are washed away by rain faster than they can accumulate on the ground?

A few small groves of trees, growing in a 2 to 4 inch thick loam, occur on Canton. Their probable origin began with a moderate guano deposit stimulating herbaceous plant growth. This resulted in the formation and accumulation of decomposing organic matter. As the soluble material washed out, a blackish soil high in phosphate remained suitable for the survival of trees. One of the soil samples collected yielded 11.4% phosphate on analysis. Perhaps it was such a phosphatic soil that was exploited by the "guano" diggers, rather than true guano.

^{1/}New York Botanical Garden.

^{2/}Formerly Botanisches Museum, Berlin-Dahlem.

Borrowing Dr. Alexander's soil auger, we entered one Messerschmidia grove near the old guano wharf to take soil samples. This was near the lagoon. Here the humus-stained layer was four inches deep, an estimated accumulation of 1,000 years. The second place for samples was a Cordia grove near the British Settlement. This was near the ocean. The humic layer was shallower; the age, less. The samples, mailed to Dr. F. R. Fosberg, were assayed by the Geochemistry and Petrology Branch of the U. S. Geological Survey, Washington 25, D. C. The results are as follows:

Sample 1 (Lab. No. 153526), top horizon in Messerschmidia grove, a dark brown sandy loam with some coral gravel that is somewhat weathered but internally clear white.

Sample 4 (Lab. No. 153527), top horizon in Cordia grove, a dark brown loamy sand with light grains, very weak structure.

Rapid rock analysis by Paul L. D. Elmore and Samuel D. Botts (methods similar to those described in U.S.G.S. Bulletin 1036-C.

	MgO	CaO	Na ₂ O	K ₂ O	P ₂ O ₅
Sample 1	1.3	31.0	.26	.03	11.4
Sample 4	2.0	44.6	.44	.02	.72

Quantitative spectrographic analysis by Nola N. Sheffey (in percent on a moisture-free basis. Dried material was ignited at 900° C for 15 min.)

	% Loss on ignition		Cu	Mn	Ni
Sample 1	46.6		.0033	.0006	.0075
Sample 4	47.3		.0018	.0002	←.0002
	Fe	Cr	Sr	Ba	B
Sample 1	.013	.0002	1.2	.002	.010
Sample 4	.004	←.0002	.50	.001	.008

Elements looked for but not found: Mo, Zn, Co.

The above quantitative results have an overall accuracy of ± 15 percent except near limits of detection where only one digit is reported.

In addition to these soil samples, foraminiferal sands were collected and the species identified. They will be reported on in a later paper together with other members of the animal kingdom.

LOCAL LANDMARKS

The SS President Taylor, briefly mentioned in Bull. 41, p. 2, is a prominent, rusting hulk near Musick Light. It still dominates the wreckage-strewn British Settlement. Why the attempt to remove it failed is an interesting tale we owe to Mrs. Betty P. Defibaugh, former postmistress.

The SS Granite State, 10,500 gross tons and an overall length of 522 feet, was launched in 1921. Two years later she was purchased by the Dollar Steamship Line and rechristened SS President Polk. She made about a hundred round-the-world trips during the next five years with passengers and freight. Dec. 5, 1941, when in San Francisco, she was requisitioned by the Government to carry 200 military personnel to Manila, the planned sailing day being December 8. As the attack by Japan on Pearl Harbor intervened, plans were changed. The vessel was rechristened SS President Taylor, quickly remodeled, and sent to Honolulu December 27 with 600 officers and men of the U. S. Tanks Corps. She then returned to San Francisco with Army wives and children.

February 3, with about 1,400 troops and equipment and accompanied by a destroyer, she sailed for Canton Island. As two Japanese submarines caught up with this little convoy near Canton, the President Taylor was ordered to steam close to the atoll. While the destroyer chased the submarines away, the ship ran aground, the troops disembarking the following day, February 15. Various attempts were made to refloat her, the last one in May, without success.

Canton being now an important war base, many of the troops stationed there visited the wreck, helping themselves to whatever they could carry away to make their living quarters ashore more comfortable. The wreck itself remained a pleasant spot to visit until gutted by fire May 1948.

The Caronia, a 300 ton steel pleasure yacht reputed to have cost \$750,000 to build in 1927, was taken over by the Navy for the duration of the war. William Cooney, formerly in the Navy, and friends, finally purchased her for a few thousand dollars. They purchased the President Taylor for \$5,200 at auction from the U. S. Maritime Commission. Incorporated as "Taylor Salvors," the eleven partners with wives and children to swell the total to 25, sailed on the Caronia for Canton with abundant salvage equipment and with food to last nine months.

The salvagers cut off most of the ship above the waterline to lighten her, and patched the holes in the hull. Thereupon they planned towing her to Japan to sell for about \$250,000. But as an irreparable crack in the hull made refloating impossible, they had to be satisfied with salvaging as much metal as possible and selling it on Canton. Expenses just about ate up profits. Then real disaster struck.

The night of July 11, 1956, the barking of dogs aboard the Caronia awakened the six sleepers just in time to enable them to jump overboard and swim ashore. The vessel was ablaze and soon a total loss. Salvage operation of the President Taylor ended, the last

partner forsaking Canton January 1957. Then March 31 the Coast Guard towed the wreck Caronia from the lagoon out to sea and sank her. The SS Granite State, alias President Polk and President Taylor still lies on the reef of Canton.

The old Pan-American World Airways hotel, where the senior writer spent a few days in 1950, has been abandoned. It had become a shambles by 1958.

Canton has improved since 1950-51 in respect to housing for CAA personnel. Many more attractive, modern homes have been built south of the Terminal Building. Some of these are surrounded by well kept gardens; a few by native vegetation and naturalized weeds.

FLORA: SPERMATOPHYTA

Bulletin 41 describes fully the native flowering plants, and lists the plant introductions made in 1950-51. Here we shall note pertinent observations about both categories, arranging the species in taxonomic order. Species which have not materially changed in status since the earlier survey will not be discussed here.

Following instructions from CAA officials in 1950, most of the early introductions were made about the CAA housing area and Terminal Building. Though we were dismayed to see most of these plants with bare, dead stems in February 1958, we were gratified to notice some of them putting forth healthy shoots from the base. The reason was not clear to us until a resident explained that this very area had been thoroughly sprayed; but instead of using the insecticide desired, the workmen in error had used a weed killer!

PANDANACEAE

Pandanus tectorius Park. of the Hawaiians is now represented by quite a number of specimens. All are restricted to gardens, and most probably stem from the 1950-51 introductions.

GRAMINEAE

Cenchrus echinatus R. Br. the sandbur, a terrible nuisance, is ubiquitous as before in areas where man is active. We mention it here because of the strange fact that it has hardly if at all increased its range since 1950-51. Near the plant nursery, now demolished west of the Terminal Building (Bull. 41, p. 39), two plants are killing and displacing this painful weed. Pennisetum setosum, because of its perennial habit, preempts areas where the annual sandbur dies of age, and takes over the ground before the germinated, bur-enclosed seeds can establish themselves. The other beneficial plant is the teaselgourd vine (Cucumis dipsaceus), which simply grows over the sandbur and smothers it to death.

Chloris inflata Link, a fingergrass, conspicuously extends over neighboring vegetation. It is common about the old plant nursery, north of the "native" village inhabited by Gilbert and Ellice Islanders, and about the British Settlement near Musick Light.

Cynodon dactylon (L.) Pers., Bermuda grass, thrives in several patches near the Terminal Building. The beautiful, green lawn existing about the home of a Hawaiian family in 1950 is gone as is its careful tender. He watered it from a brackish well he had sunk in his own garden.

Digitaria henryi Rendle, a 1950-51 introduction, is established and forms small mats in the shade of the coconut trees about the guest house near the lagoon, British Settlement (Deg. & Deg. 24,647).

Digitaria pacifica Stapf, the native bunch-grass, is variable, as mentioned in the previous bulletin. Along the lagoon, north of the native village, is a form (Deg. & Deg. 24,638) that extensively creeps to build up a huge, loose clump about 50 feet across. At the east end of the north Landing Strip, on the other hand, grows a very compact, dwarf specimen. Residents should keep such aberrant plants under observation to determine whether they are merely ecological forms or, instead, genetic ones worth describing.

Digitaria sanguinalis (L.) Scop., crabgrass, if this difficult grass is correctly identified, grows here and there about the nursery area. It is reseeding itself.

Digitaria timorensis (Kunth) Bal. is still growing in the same areas as in 1950-51. Now, however, it is likewise naturalized in dense but localized patches in the plant nursery area (Deg. & Deg. 24,645). Because of its perennial nature, it appears to be crowding out sandbur.

Eragrostis amabilis (L.) W. & A., the feather lovegrass, is a delicate annual thriving here and there about the British Settlement. In the garden of the Terminal Building it forms a dense, tangled lawn, tending to crowd out all other herbs. Just before our departure from Canton in late February 1958, we were amazed to see all this grass being uprooted and hauled away to leave a glaring white surface of coral shingle. Such an area becomes ideal for sandbur to take over. This little garden spot, seen by every voyager, needs a two to three inch covering of screened soil, still quite plentiful near the old guano wharf. Then the area should be mowed regularly every month by a light hand lawn mower, whether it appears to need it or not, the gardener being careful not to let the wheels of the machine cut into the soil. Taller herbs will thus be discouraged from growth and, if the original workmen in February 1958 were not too efficient in eradicating every trace of it, perhaps the lovegrass will establish itself again from random seeds left in the neighborhood.

Eragrostis whitneyi Fosb., the lovegrass named for my young friend, the late Leo Whitney, has perfected a means of racial survival in this sun-scorched atoll by having shortened its life cycle to a scant three or even two weeks. February 1 we discovered a single tiny plant beginning to flower at the swimming hole near the lagoon, northwest side.

By February 16 the species was very common locally, also actually on the Fighter Strip where no other flowering plants could gain a foothold, and here and there on the road at the southeast side. In the latter place it was among blue-green algae (Microcoleus acutissima and a little Schizothrix longiarticulata) that were binding the dusty sand together. This native grass does not grow in rubble, like Lepturus, but in firmly compacted sand and coral fill. Perhaps in such terrain, soil moisture can more easily rise by capillary action to where the shallow roots are located. The life span of this grass is even too short for the scale insect (Antonina graminis (Maskell) det. Miss Amy Suehiro) to grow to maturity about its rootstock.

Lepturus pilgerianus Hansen & Potztl (1954) is of special interest. It is the only annual in the genus. Fosberg states, "The supposed annual habit of L. pilgerianus is especially meaningless to any one who has seen L. repens extensively in the field, as this feature is a purely facultative one, depending on the climate at certain stages in the life of the plants." This is a bold statement, particularly as the critic admits not having seen the type specimen. O. Degener spent a total of ten weeks botanizing on Canton; I. Degener spent three. The Degeners here reaffirm their previous finding that L. pilgerianus is annual. Furthermore, this annual plant differs from the perennial Lepturus growing with it in having culms red-violet not green toward the base, in forming a narrower and less congested tussock or "bunch," in having leaves smooth rather than rough, in lacking obviously the dead culms and leaves of previous years' growth found in the perennial, and in the inflorescences at a distance appearing more conspicuously separate from the rest of the tussock. L. pilgerianus grows on both sides of the lagoon, being especially abundant near the Fighter Strip. Though passage was available for the asking on a Government vessel to neighboring Enderbury Island in February, due to an oversight the writers missed the opportunity of going there to ascertain the possible presence of L. pilgerianus.

Lepturus repens (Forst. f.) R. Br., though recorded from Canton in practically all previous papers, actually does not occur there in the narrow sense (var. repens). The Canton plant is either the variety subulatus, originally described from Ujelang, Marshall Islands and widely distributed in the Pacific, or a variety still undescribed. The Ujelang plant "tends to be stoloniferous," a tendency foreign to the Canton plant.

Panicum distachyum L. (Deg. & Deg. 24,649) is a new record for the atoll. It forms dense mats in the British Settlement. One large clump (Deg. & Deg. 24,656) grows against the ruins of the PAA hotel, in a spot that receives rainwater from the roof.

Panicum miliaceum L., growing near the PAA hotel in 1950 and thought to be derived from spilled birdseed, has disappeared.

Pennisetum setosum (Swartz) L. Rich., introduced in 1950-51, covers an acre or two near the plant nursery to the exclusion of almost every other plant. Clumps occur sporadically elsewhere in the general neighborhood. Largely because of its perennial habit, as already

mentioned under Cenchrus, it crowds out the annual sandbur. Like so many other introductions, Pennisetum has not extended its range extensively. These writers therefore in 1958 gathered many seeds, better termed grains, and scattered them in likely places. This grass and Cucumis dipsaceus (p. 16) vie among themselves as the most valuable introduced sand binders.

Setaria verticillata (L.) Beauv., the bristly foxtail was, next to the sandbur, the most troublesome weed in 1950-51. It was everywhere near human activity, the coarsely hairy, fruiting inflorescences tangling themselves in socks and stockings of anyone straying from the center of a pavement. But during a three weeks' stay on Canton in February 1958 the writers found only two or three clumps. One of these was about a box of garbage that had been dumped on the roadside northwest of Turtle Beach. We do not know why this annoying weed has suddenly almost disappeared.

Tricholaena rosea Nees, Natal grass, is now naturalized widely in the nursery region, about where it was first introduced in 1950-51.

CYPERACEAE

Cyperus javanicus Houtt., introduced in 1950-51, grows well in clumps between the nursery and the ocean (Deg. & Deg. 24,650).

Cyperus polystachyos Rottb. (Deg. & Deg. 24,655) grows in several clumps in the shade of coconut trees near the lagoon about the British Settlement. It is a welcome addition to the local flora, not recorded before.

Cyperus rotundus L., the nutgrass, still grows about the old PAA hotel site; now also about the Terminal Building.

Fimbristylis dichotoma (L.) Vahl, growing in 1950-51 near the outdoor theater of the time, south of the British Settlement; and F. pycnocephala Hbd. growing on a barren plain near the CAA housing area of the same time, are still there. By 1958 they had spread to the northwestern part of the atoll, conspicuous and valuable sand binders of open areas everywhere. The latter resembles a coarse pincushion. The two species often grow together, and we noticed evidence of hybridization.

ARECACEAE (PALMAE)

Cocos nucifera L., the coconut, now grows abundantly in gardens. Many are given a little care and hence are thriving. Only one tree, however, is now old enough to begin bearing. The healthiest trees, even though infested with scale, are in Dr. King's garden. They had been set in pani or depressions below the surface of the ground, holes dug deep enough to penetrate the hardpan. They were surrounded by large slabs of limestone tipped so as to lead an unusual supply of water to them at every rain, and were occasionally supplied with a little water left over after household use. This last treat will be hardly necessary after the roots have penetrated to near the brackish ground water table.

Phoenix dactylifera L., the date palm, was considered such a valuable food plant in case of emergency on Canton that thousands of its seeds were scattered in 1950. Many germinated and Dr. S. G. Ross set out a score or so seedlings about his hospital in 1951 south of the British Settlement. In 1958 only two small date palms were growing on Canton, cultivated in a garden.

COMMELINACEAE

Rhoeo spathacca (Sw.) Stearn, the white-flowered tradescantia or "oyster plant," was introduced in 1950-51. It grows well in some gardens.

Setcreasea purpurea B. K. Boom is cultivated about one home, and doing well.

LILIACEAE

Sansevieria cylindrica Bojer and its relative S. guineensis (Jacq.) Willd. introduced in 1950-51 are planted in gardens. None has become naturalized.

AMARYLLIDACEAE

Crinum asiaticum L., or a species thus called in Hawaii and elsewhere, is planted commonly about homes. It is often grown crowded together, although it needs to be thinned to individual plants to get best results.

Furcraea foetida (L.) Haworth, incorrectly listed as F. gigantea in Bull. 41 and by botanists in general, was introduced in 1950-51. It is growing in a few gardens.

MUSACEAE

Musa nana Lour., the Chinese banana, was cultivated in a few gardens in 1958 to the exclusion of other kinds also grown in 1950-51.

CASUARINACEAE

Casuarina equisetifolia L. and C. glauca Sieb. are both thriving without care, the latter increasing its area slightly by producing from its spreading roots adventitious buds that grow into new trees.

POLYGONACEAE

Coccoloba uvifera (L.) L., the seagrape, was already growing and fruiting about the PAA hotel in 1950. But as Degener had a thriving tree in his garden at Mokuleia Beach, Oahu, he gathered the abundant seeds fallen on clean sand. This was more practicable than searching for and gathering the few that fell among sandbur and foxtail under the Canton Atoll trees. The Oahu seeds were planted on Canton. By 1958, the old original seagrape trees had formed a beautiful, small shady grove about the hotel grounds. Ripening fruit was everywhere, and "native" urchins were gathering them into tin cans as a source of food. The trees were reseeding themselves and can furnish sufficient seedlings to form shaded roadsides

and gardens throughout the atoll if given a minimum of care. Volunteer seedlings, if left under the old trees die within a few years. Seed scattered about by Degener in 1951 had grown into a few low, spreading bushes about the bird refuge, and those planted south of the housing area were healthy and thriving. A few were planted at the Gillaspys home and, according to reports, were six feet tall in 1958 before they were uprooted and discarded by a new resident.

AMARANTHACEAE

Amaranthus dubius Mart. was not observed during our 1958 stay.

AIZOACEAE

Sesuvium portulacastrum var. griseum, first described by Degener & Fosberg as new from Canton, is still growing in the same areas as before. But in 1958 at the Dock a patch of the species, var. portulacastrum. (Deg. & Deg. 24, 651) was found naturalized. It is obviously of recent accidental introduction, seeds presumably reaching this spot with shipping. The difference between the slender, red-stemmed, red-flowered, glossy, terete-leaved var. portulacastrum and the stocky, yellow-stemmed, pale-flowering, dull, angular-leaved variety griseum is striking when the two grow side by side.

PORTULACACEAE

Portulaca cyanosperma Egler, a Hawaiian purslane with pretty violet-red flowers, was introduced in 1950-51. Mr. & Mrs. Albert Lincoln reported the former occurrence of large mats of this succulent near Turtle Beach, northeast side of Canton. They transplanted some to their garden near the lagoon where the writers happened to see it and its escaping offspring. A visit to the former Turtle Beach stand disclosed that waves of a recent, severe storm had washed over this area, sweeping all vegetation in their path, except Suriana, into the lagoon.

CARYOPHYLLACEAE

Spergularia marina (L.) Griseb., a pale, fleshy halophyte (Deg. & Deg. 24, 612), was collected on Johnston Island January 30, 1958. Its seeds were scattered about the new hospital in the CAA housing area on Canton a few days later.

CASSYTHACEAE

Cassytha filiformis L., the love-vine, is native to Canton. It now covers like a huge greenish throw-net several acres near the Shark Pool, parasitizing Portulaca lutea, Boerhavia and Sida.

CRUCIFERAE

Lepidium o-waihiense Cham. & Schlecht., introduced from Oahu in 1950-51, is surprisingly abundant (Deg. & Deg. 24, 636) and even crowded in 1958 on part of the elevated side of the causeway south of the "native" village. The writers gathered several handfuls of seeds to scatter in other likely places.

CRASSULACEAE

Bryophyllum pinnatum (Lam.) Kurz, the air-plant so famous for producing plantlets from notches in its leaf even when the latter is pinned on a window curtain, is now growing in a few gardens. It has not escaped, but should be encouraged to do so.

LEGUMINOSAE

Desmanthus virgatus (L.) Willd., the slender acuan, was introduced in 1950-51. Numerous branches of this shrub stand stiffly upright about the nursery area, killed by the weed spray. Luckily two or three root-stocks survived the poison, and in February 1958 bore flowering branches.

Leucaena glauca (L.) Benth. (haole koa in Hawaii) was already represented by a few fruiting plants in 1950 at the PAA hotel entrance. Degener in 1950-51 introduced many seeds. Now this plant is sparsely re-seeding itself about the British Settlement, and fairly well in the nursery area, even though recently exposed to the weed spray.

Prosopis chilensis (Molina) Stuntz, the algaroba, is a shallow-rooted tree related to the deep-rooted mesquite of the southwestern part of the United States and northwestern Mexico. As stated previously (Bull. 41, p. 33), the Degener-Gillaspy policy was to introduce no plants that might be poisonous or painfully thorny "such as the . . . algaroba (Prosopis chilensis)". Nevertheless, in 1958 we were pleased to see a dainty algaroba growing in a flower pot on a resident's porch. There is a vast difference between algarobas growing under proper confinement and such trees growing wild to scatter their cruelly efficient thorns where such a large proportion of the population goes barefoot.

EUPHORBIACEAE

Acalypha wilkesiana M. -A., the painted copperleaf, had disappeared by 1958, but the three Chamaesyce species were as common as before. They had not materially extended their range.

Phyllanthus "niruri", "growing in 1951 in and about a box of soil imported from Fiji," had established itself about the British Settlement, but was rare in 1958. When this specimen (Deg. & Deg. 24,646) is studied further it will probably be shown to be another species, as according to G. L. Webster (1956) P. niruri L. though widely reported, does not occur in the Pacific Islands.

Poinsettia cyathophora (Murr.) Kl. & Garcke), the fiddle-leaved poinsettia, in 1950 was sparingly naturalized and protected in the British Settlement; but not observed elsewhere. In 1958 this modest ornamental was growing wild and common in the housing area. When the plants flower, thirsty flies and other insects are attracted to the nectar. Some housewives therefore keep the plants from growing near their homes. The garden poinsettia (P. pulcherrima (Willd.) Graham) was nowhere to be seen. It is worth introducing again as a garden plant.

ANACARDIACEAE

Schinus terebinthifolius Raddi, the Christmasberry tree, is represented by a small healthy plant in a garden near the airport.

MALVACEAE

Gossypium brasiliense Macf., the kidney-cotton of commerce, was introduced in 1950-51 about the CAA housing area. Several years later it was abundant, and conspicuous with its untidily spilling seeds and white lint. After the disastrous spraying of the area with weed killer, this choice ground cover was killed except for a few score plants. These were producing their crop of cotton in 1958, and some of the seeds were planted at that time. The endemic Hawaiian cotton (G. tomentosum), likewise introduced in 1950-51, is nowhere to be seen.

Hibiscus rosa-sinensis L., the common Chinese hibiscus, is growing in a few gardens as before. The plants are chlorotic.

Pariti tiliaceum (L.) Britton (hau in Hawaii) was already on Canton when Degener introduced many seeds from Oahu in 1950-51. In 1958 the tree was rarer than before; the old one at Musick Light still lives.

Sida fallax Walp. is almost everywhere as before. Near the garbage dump south of the housing area grows a freak bush with almost white flowers.

Thespesia populnea (L.) Sol. (milo in Hawaii) still grows on Canton. In spite of the numerous seeds introduced in 1950-51, it is represented by only a few more individuals in 1958.

CLUSIACEAE (GUTTIFERAE)

Calophyllum inophyllum L. (kamani in Hawaii) was already on the island before Degener imported seeds and potted plants in 1950-51. The old trees of 1950 about the PAA hotel are growing well.

TAMARICACEAE

Tamarix aphylla Karst., the European tamarix, is represented by the same beautiful, large trees that were growing about the hotel in 1950. Cuttings from Oahu set out by Degener in 1950 about the Weather Station had been accidentally killed by the weed killer except for one tree that has become ten feet tall. This represents a growth of almost one foot per year.

PASSIFLORACEAE

Passiflora foetida L., the foetid passionflower, was represented by a single plant in 1950 before Degener introduced and scattered hundreds of seeds. In 1958 it was naturalized about the plant nursery and British Settlement. The long vines are flowering, bearing their edible fruit, and reseeding themselves.

CARICACEAE

Carica papaya L., the papaya, was planted as before without following the writer's suggestions of adding humus in the soil about it (Bull. 41, p.26). As expected, the trees were chlorotic and non-fruiting.

COMBRETACEAE

Conocarpus erecta L., introduced in both the glabrous and silvery varieties by Degener in 1950-51, are beautiful shrubby trees in the Terminal Building garden. The ground under the trees is covered with seedlings available for replanting. They have not been used and gradually die due to competition with the parent plants.

Terminalia catappa L., the Indian almond, was already on Canton when Degener introduced seeds and seedlings in 1950-51. The Degener introductions were nowhere to be seen in 1958, whereas the old trees of 1950 about the PAA hotel are not only growing well but reseeding themselves. Young plants up to a foot high are under the old ones just waiting to be transplanted.

ARALIACEAE

Polyscias guilfoylei (Bull) L. H. Bailey, the panax of Hawaiian residents, is now growing in a garden or two in the housing area.

APOCYNACEAE

Plumeria rubra L., the frangipani, was introduced in a cultivated form previous to 1950, and died that year due to scale insects. Offspring of wild trees originally gathered in the Bahamas by Degener and planted by him on Canton in 1950-51 have disappeared. These bore small, white flowers. A single plant of a cultivated form, obviously recently introduced, now grows in a garden.

Calotropis gigantea (L.) Ait. and its white-flowered form wilderi Degener, the crown flowers, are grown with success in both the British Settlement and the CAA residential area. As these milkweed are host for the caterpillar of the monarch butterfly, some residents destroy their plants rather than bother to kill the insect with a spray or by hand picking. We are not certain whether the lavender crownflowers in gardens come from cuttings imported in 1950-51 or are from the ancient bush still growing between Musick Light and the wrecked "President Taylor."

The variety wilderi, in the original description by the senior writer in 1937, was stated to have been introduced into the Hawaiian Islands "by Gerrit Wilder "from Tahiti, where he found it, growing in the garden of Robert Keable, writer.'" More recent evidence indicates that Wilder erred in claiming he had first introduced this plant into Hawaii. It had been growing there years before his introduction. Whether it originated in the Hawaiian Islands, Tahiti or elsewhere is still an open question.

CONVOLVULACEAE

Ipomoea tuba, which was not identified with certainty in Bulletin 41, p. 27, is a correct scientific name for the native moonflower. This twiner is represented by the same old plants observed in 1950-51 along the northeastern rim. It has not spread of its own accord since that time. The few seeds lying about the dormant plants in 1950-51 were gathered and planted about the CAA housing area. It was refreshing to see this night-bloomer cover now almost an acre of rubble where the two Landing Strips meet, and to see a patch a hundred feet wide covering Sesuvium just south of the housing area. A few moonflowers are being successfully trained on trellises. The plant is beautiful at night with its large, gleaming white flowers facing the stars overhead.

Ipomoea batatas (L.) Poir., the sweet potato, was observed in 1958 planted in the open in the housing area. It thrives except for chlorosis.

Ipomoea pes-caprae (L.) Roth, the beach morning-glory, frequently recorded from Canton, is probably represented only by the subspecies brasiliensis. We do not know whether we should classify it as native or introduced; it is a borderline case. So far as its seeds drift to Canton and germinate there, it is a native. But due to the terrestrial hermit-crab (Coenobita perlatus), such plants never survive. We now believe the only plants able to mature receive some human protection. In this sense, the beach morning-glory must be classed as introduced. In February 1958, hundreds of thousands of beach morning-glory seeds were seen washed up in an almost solid line along the north shore of Canton. With several other species of various families, they germinated well enough to mark a thin greenish line along the beach. The characteristically shaped cotyledons were soon devoured and not a seedling was observed with normal, goat-footprint leaves. Yet about the hotel area and CAA housing area, where Degener planted Oahu seeds in 1950-51, the vine was common, covering the ground with its long, flowering, creeping stems. These even covered the bare floors of the large Quonset huts near the lagoon beach. Though a prostrate creeper, not a high twiner like the moonflower, the slender stems were successfully trained by some residents over fences near the Terminal Building to produce a truly charming effect.

BORAGINACEAE

Cordia sebestena L., the geigertree, thrives in spite of neglect in the old PAA hotel grounds. Its roots, like probably those of all the various kinds of older trees in the vicinity, may have reached to near the watertable. There, one must remember, the water is but mildly brackish. The ground under the geigertrees is covered with healthy seedlings, material that could be nicely planted in gardens and along the roads of the CAA housing area.

Cordia subcordata Lam. (kou in Hawaii) may be native according to some evidence; originally introduced by man according to other. For example, during our rather thorough search for drift material we failed to find a single kou fruit, notwithstanding that they are corky and hence admirably suited for ocean transport. About the present kou groves, where hermitcrabs congregate mainly to enjoy the shade, the seeds

readily germinate but the writers have yet to find a single one escape crab destruction to grow to maturity. The opportunity for a rare seed during the atoll's life-time to reach a favorable spot, to be covered with sand and germinate, and finally to mature in spite of hungry crabs is entirely possible but unlikely. Furthermore, clusters of kou trees about the old guano wharf "are said to have been planted years ago (Bull. 41, p. 28)." That leaves the two groves, less than one mile south of Musick Light, to consider. The one covers about 3500 square feet and the other about 2700 (Bull. 43, p. 3). The soil in the former, according to Dr. Alexander's estimate to us on the spot, is several hundred years old. Do these old kou groves, each probably derived from a single fruit, represent an introduction several hundred years ago by ocean currents or by early Pacific Islanders, perhaps those who may have erected coral rock edifices (Bull. 41, p.6)?

Even though the kou was already there, Degener shipped a large quantity of fruits from his Mokuleia Beach, Oahu, trees to Canton in 1950-51 to add to fruits gathered by him locally. Then while hunting for and studying specimens south of the housing area, he was wont to wander over the area, a shovel in the right hand, and a pail with vials, killing bottle, flask of water and kou fruits in his left. At various spots he thrust his shovel a few inches into the friable soil, moved it back and forth a few times, threw a small handful of fruits in the gaping hole, and tamped the soil about them. In 1958, the landscape, thanks to this early planting, was dominated by vigorous clumps of kou trees, each about six feet tall and seven or eight years old. The very minimum care in planting combined with isolation, that made it difficult for crabs to find everyone of the thousands of tasty seedlings, was sufficient to establish groves of this tree. Defoliation by caterpillars, an ugly nuisance to which all kou are presently subject, will be lessened thanks to Territorial Entomologist G. C. Chock of Honolulu. He is preparing to ship the proper parasite for control.

VERBENACEAE

Stachytarpheta jamaicensis Vahl, called oi in Hawaiian, is native to tropical America. The small quantity of seed available was scattered in 1951 mainly about Degener's cottage near the lagoon south of the PAA hotel. In 1958 the oi was locally abundant and naturalized. The only other station observed that year was at the garbage dump, south of the CAA housing area. This consisted of a single large plant, in that area decidedly ornamental with its pale lavender flowers. Because of their contrast against a field of yellow Sida, its scanty sprays were being picked for ornament. Its popularity may yet cause its death. At the abandoned cottage, on the other hand, the plants can continue to blossom and reseed themselves undisturbed.

SOLANACEAE

Capsicum frutescens L., the common redpepper often called "Chili pepper," is more than holding its own in a garden.

Lycopersicum esculentum var. commune Bailey, the common tomato, was evidently recently introduced and thriving in a garden. L. esculentum subsp. galeni (Mill.) Buckwill, a wild tomato with small fruits naturalized on Oahu, was hopefully introduced in 1950-51. Not a single plant was to be seen in 1958. "Lycopersicon esculentum var.", collected near the Airport by Degener & Hatheway (No. 21,307) in 1950, was likewise gone. It resembles a plant from the Galapagos (Alban Stewart No. 3,380), and like it is a straight variant of L. esculentum.

Nicotiana glauca R. Grab., the tree tobacco, already in Canton in 1950, was reintroduced by Degener the following year. In 1958 one huge plant, a respectable tree, grew in a depression north of the north Landing Strip close to the ocean. It had been badly mauled by a storm, but was recuperating well from its injuries. It had reseeded itself prolifically during the past years, and the younger plants, likewise injured during the same storm, were likewise growing lustily. Other plants growing elsewhere often become chlorotic.

Petunia hybrida Nilm, the common garden petunia, grows nicely in a window-box. Such prized plants almost always receive a little care, some water left over after rinsing a vegetable or the dishes, perhaps even a little commercial fertilizer. Such ornamentals are well worth growing, but hardly can be expected to escape into the wide open spaces where such little extra care is denied them.

Physalis angulata L., the husk tomato, is found, as in 1950, sparingly naturalized at the British Settlement. This time it has spread to the Terminal Building garden. Here the plants suffer from the attacks of red spiders.

Solanum melongena var. esculentum Nees, the eggplant, grows in a garden. It promises a crop.

RUBIACEAE

Casasia clusiifolia (Jacq.) Urban, perhaps best named the Bahama gardenia, was introduced as small plants in 1950-51. Seeds, collected by Degener many years ago along the arid coral coast of New Providence, British West Indies, were sent to Colin Potter, custodian of Foster Botanical Gardens, Honolulu, for cultivation and distribution. In 1951 Mr. Potter kindly donated some healthy, six-inch plants for Canton, which were forthwith set out at the Terminal Building. In 1958, though somewhat infested with scale insects, the Bahama gardenias had developed into beautiful compact shrubs, three to four feet high, with dark, glossy leaves and sweetly fragrant, gardenia-like flowers. Even the large orange fruit, edible in an emergency, was setting but we do not know whether its seeds will be viable. This ornamental evergreen is highly recommended for planting in local gardens.

Morinda citrifolia L., (noni in Hawaii) was known to Degener in 1950 by a single large tree near the old guano wharf. It had disappeared by 1958. At that time, however, a large, but dilapidated tree was growing in the "native" village and, according to a Gilbertese, several more were growing east of the north Landing Strip. The variegated var. potteri Degener, introduced by Degener originally from Viti Levu, Fiji, planted in 1950-51, was nowhere observed.

CUCURBITACEAE

Citrullus vulgaris Schrad., the watermelon, was planted in one garden.

Cucumis dipsaceus Ehrenb., the teaselgourd of Arabia, was introduced in 1950-51. At the old nursery in 1958 it had covered one area 50 feet across, and was growing in several more places in the vicinity. In the former locality this vine formed a luxuriant, densely leafy ground-cover, smothering out every other plant in the area, including the obnoxious sandbur (p. 4). The ground was covered with golden yellow gourds, many of which were gathered, sliced and scattered in likely places. Though this interesting plant finds Canton to its liking, it seems not to spread much farther than its slender extending vines can drop their seed-filled gourds upon the ground. An efficient animal for proper seed-dispersal is wanting. Grown for ornament and curiosity in many lands, it is strange no island resident has trained the teaselgourd over fences and trellises like the moonflower and the less adapted beach morning-glory.

Cucumis melo L., the muskmelon, thrives in one garden, the vines covered with unripe melons two to three inches in diameter. Even if they do not ripen, they can be made into a conserve or pickle. According to Mr. Beardslee, many ripened.

GOODENIACEAE

Scaevola, the naupaka of Hawaiians, consisted of two kinds of plants on Canton in 1958: the native one, common almost everywhere; and the Hawaiian one, consisting of less than a dozen plants derived from Oahu seeds scattered in 1950-51. To have these two kinds growing together under identical conditions was ideal for their comparison and study. The Canton plant becomes ten feet tall; has glossy, hairless leaves; and white flowers in which the corolla lobes are marginally narrow-winged and slightly fimbriate. The Hawaiian plant, on the contrary, rarely attains half that height; has finely velvety leaves; and white to more or less lavender flowers in which the corolla lobes are marginally broader-winged and more prominently fimbriate. Residents of Canton, without any botanical knowledge, had noticed the difference between the two even before our arrival from Honolulu.

The coastal species of Scaevola on Canton and other Pacific Islands has white fruit and has most often been called S. frutescens (Mill.) Krause. Fosberg (1956) has demonstrated that this name can be applied only to the Atlantic coast Scaevola with black fruit, which the writer knows well from Bermuda and the Bahamas. Fosberg concluded that the only name available for the Pacific species is Scaevola sericea Vahl (Symb. Bot. 2: 37, 1791). This was described from Niue (Savage Island) east of Tonga and the name can best be translated as silky scaevola. While the Canton plant is nowhere silky, we tentatively call it S. sericea until further studies determine whether another name is necessary.

The common Hawaiian plant has been called variously S. lobelia, S. frutescens, S. frutescens var. sericea and S. fauriei. We know it cannot bear any of the three first names. We likewise believe it is not sufficiently distinct from the Niue plant to have a specific name of its own. We therefore (Phytologia 6(6): 321, 1958) named the Hawaiian plant Scaevola sericea var. fauriei Degener & Degener.

Now that two related naupaka grow on Canton, it will be interesting to note whether they will hybridize.

COMPOSITAE

Conyza canadensis (L.) Cronq. (Deg. & Deg. 24,961) is represented by about a dozen plants. These grow about a warehouse southwest of the Terminal Building, mostly under the eaves of the roof, perhaps because of the additional water that occasionally drips from them. This plant is new for Canton, an accidental introduction.

Gaillardia picta Sweet, a variable form of hybrid origin naturalized on dunes about Laie, Oahu, was sown around the Terminal Building in 1950. In 1951 several plants had already flowered, most of them under the eaves of old shacks. In 1958 the shacks were gone, and the Gaillardia as well. With a little care, this ornamental would reward the gardener with an abundance of pretty flowers varying from yellow to orange-red.

Pluchea indica (L.) Less. , the Indian pluchea, was introduced in 1950-51. It is thriving and common about the Turning Basin. It now grows among its coarser, grayer relative P. odorata (L.) Cass.

Tagetes sp., the marigold, was observed cultivated in a window box.

CYANOPHYTA^{1/}

Cyanophyta (Myxophyceae, Cyanophyceae) commonly called blue-green algae because of their prevailing color, are extremely important in keeping the sand and the coral dust of Canton Island from blowing away.

Some "blue-greens" form a felt-like covering near the surface of the soil; some cover the soil with a gelatinous matrix; others evidently combine with bacteria to form a thin layer of stone; while still others are apparently of no value at all as soil binders. When Canton suffers from an exceptionally long drought, some of the felt-like blue-green algae curl up in leaf-like flakes and eventually may crumble into dust, thus exposing the loose sand and soil as well as themselves to wind erosion.

Of course a ship or plane may have unwittingly transported different kinds of blue-greens from one island to another. Perhaps because of such agency of man, Entophysalis deusta and Microcoleus

^{1/}Remaining groups of algae in the Degener Collection are described by E. Yale Dawson as Bull. 65.

chthonoplastes were collected on both Canton Atoll and Johnston Island (Deg. & Deg. 24,580 and 24,580a, Jan. 30, 1958). The consensus of botanists, however, is that such microscopic organisms are readily transported even by high air currents throughout the world. To be wafted from Canton to Johnston or vice-versa is not a difficult feat, one that probably occurred time and time again. Many blue-greens are capable of survival on sun-scorched rocks, as found on Canton, on the Equator; and in the thermal springs, as in Yellowstone and New Zealand. Such plants are likewise capable of survival and growth in frigid regions.

Thanks to Dr. Francis Drouet's efficient advice on the collecting of Cyanophyta received before our February 1958 stay on Canton and thanks to his expert determinations, we have the following to report:

CHROOCOCCACEAE

Anacystis aeruginosa (Zanard.) Drouet & Daily (Deg. & Deg. 24,744).

Anacystis dimidiata (Kütz.) Dr. & Daily (Deg. & Deg. 24,584, Feb. 16, 1958), with Entophysalis deusta, was found along the southeast beach of the lagoon in shallow water gently rippled by wave action. It imparted to the fine, almost muddy, white sand, a pale pea-green color. Mixed with Johannesbaptistia pellucida and Lyngbya aestuarii which see.

Anacystis montana (Lightf.) Dr. & Daily (Deg. & Deg. 24,571, Feb. 3, 1958) occurred as a thin mat about one mile east of the Fighter Strip along the wet edge of a more or less permanent shallow, narrow pond. Various kinds of fish must have washed over the beach into this pond during severe storms but we found only mullet. The reason they could survive while the others did not was evident on tasting the water. It was almost fresh.

Johannesbaptistia pellucida (Dick.) W. R. Taylor & Dr. (Deg. & Deg. 24,573, Feb. 8, 1958), commixed with Entophysalis deusta, Anacystis dimidiata and Plectonema terebrans, formed an almost black blue-green mass at the bottom of a fresh-water pond behind the beach near the Messerschmidia woodland shown on Mathew's map (Bull. 43) near the center of the north shore.

CHAMAESIPHONACEAE

Entophysalis deusta (Menegh.) Dr. & Daily (Deg. & Deg. 24,594, Feb., 1958) is the microscopic plant that by its astronomical numbers imparts to the atoll a dark grayish somberness excepting where displaced by the green of other vegetation, the gleaming pale yellow to pink of the beach sand, the white of wave-worn coral slabs, and the indescribable pale greens to aquamarine blues of lagoon and ocean. This so-called blue-green alga covers the upper surface of coral slabs, barely penetrating beyond superficial interstices. Though useful in cutting down the glare of the otherwise alabaster-white coral rock, no one has yet worked out to what extent its absorption of the sun's rays raises the temperature of its surroundings. Considering the climate, these primitive plants are sun-scorched and dormant most of the time, springing

into life during occasional rains and ocean mists; or at night when much of the atoll is covered by a film of moisture readily formed on surfaces impregnated with ocean salts. This same plant, in conjunction with bacteria on and about decaying plant and animal debris, formed a firm 8 mm. thick crust about a drying, brackish pool on Spam Island (Deg. & Deg. 24,593, Feb. 19, 1958). Even an arid undermined ledge of limestone overhanging the lagoon bore this persistent, difficult-to-kill plant on both its surfaces (Deg. & Deg. 24,568, Feb. 8, 1958). It (Deg. & Deg. 24,564, Feb. 14, 1958) even blackened the limestone bottom of a drying, shallow arm of the lagoon six miles east of the Fighter Strip. It is almost everywhere, and hence it would be repetitious to list all our collections.

To realize fully the frequency and island-wide distribution in various habitats of this species, it is merely necessary to peruse the paragraphs below concerning other species and to learn that E. deusta was growing with many of them.

OSCILLATORIACEAE

Hydrocoleum comoides (Harv.) Gom. (Deg. & Deg. 24,918, Feb. 1958) was found on the lagoon side east of the north Landing Strip. For another collection (Deg. & Deg. 24,576a, Feb. 3, 1958) see under H. glutinosum of same number.

Hydrocoleum confluens (Setch. & Gardn.) Dr. (Deg. & Deg. 24,727, Feb. 2, 1958) grew on reef rocks, in shallow water at low tide, northwest of the Gilbert-Ellice Village.

Hydrocoleum glutinosum (Ag.) Gom. (Deg. & Deg. 24,578, Feb. 2, 1958) stained patches of muddy sand a light green. This was common on the ocean reef, shallow at low tide, southwest of the Terminal Building. The same species (Deg. & Deg. 24,576, Feb. 3, 1958) and some H. comoides were collected about 10,000 feet east of the northwest tip of Canton. Here on the ocean side is a limestone reef so flat and smooth as to remind one of a concrete sidewalk. In many areas a very fine white sand with a light bluish green color covered this rock to a depth of about one centimeter. Instead of being washed away by the waves of the open ocean, this sand remained, probably held in place by the gelatinous secretion of H. glutinosum and the less abundant H. comoides.

Hydrocoleum lyngbyaceum Kütz. (Deg. & Deg. 24,916, Feb. 18, 1958) grew on the ocean reef, south shore, in company with the former species; and (Deg. & Deg. 24,785, Feb. 6, 1958) with Spirulina tenerima Kütz.

Lyngbya aestuarii (Mert.) Liebm. (Deg. & Deg. 24,577, Feb. 7, 1958) occurred for a depth of half a centimeter or less in the calcareous sandy mud exposed at low tide along the artificial channel southwest of the Turning Basin. Another collection (Deg. & Deg. 24,583, Feb. 14, 1958) was made six miles east of the Fighter Strip in a fresh to brackish water puddle, slowly drying out. This Lyngbya, with an admixture of Entophysalis deusta, covered the area with a dark bluish green, somewhat gelatinous mat a few millimeters thick. With Anacystis dimidiata, it (Deg. & Deg. 24,565, Feb. 18, 1958) formed a

very dark blue-green covering over the bottom of a slightly saline, shallow pool on the lagoon side of the southeastern tip of Canton. Regarding still another find of L. aestuarii (Deg. & Deg. 24,592a, Feb. 19, 1958) see Phormidium gardnerianum.

Lyngbya confervoides Ag. (Deg. & Deg. 24,770, Feb. 17, 1958) grows on old coral on the ocean reef, shallow at low tide. The spot is on the south side, two miles east of the Kou forest.

Lyngbya infixa Frey (Deg. & Deg. 24,745) on L. majuscula (Dillw.) Harv.

Lyngbya majuscula (Dillw.) Harv. (Deg. & Deg. 24,749).

Lyngbya semiplena (Ag.) J. Ag. (Deg. & Deg. 24,575, Feb. 5, 1958) grew along the north shore, quite a distance inland from the beach. Though exposed to full sunlight, it bound the sand together for a thickness of three to five millimeters. A quite different habitat for this species (Deg. & Deg. 24,917, Feb. 8, 1958) was old coral forming the submerged part of the guano wharf in the lagoon. At the bird reservation, on the other hand, it (Deg. & Deg. 24,775, Feb. 16, 1958) formed a thin brown film on that part of the ocean reef that is partly exposed at low tide.

Microcoleus acutissima Gardn. (Deg. & Deg. 24,579, Feb. 14, 1958) with Schizothrix longiarticulata, grew on the flat bulldozed rubble surface of the Fighter Strip, to some extent inhibiting the formation of dust clouds. In part of this area, among the alga, grew the native dwarf lovegrass, Eragrostis whitneyi.

Microcoleus chthonoplastes (Fl. Dan.) Thur. (Deg. & Deg. 24,597, Feb. 13, 1958), with Entophysalis deusta, was collected at the southeast end of the lagoon. At low tide these extensive mudflats, here and there inhabited by colonies of gaudy fiddlercrabs (Uca tetragonon), are sun-baked and occasionally even entirely dried. Here one or both of these blue-green algae, perhaps in conjunction with bacteria, form a stiff, brittle crust of rock about one millimeter thick. One mile west of Shark Pool, southeast tip of Canton, M. chthonoplastes (Deg. & Deg. 24,581, Feb. 15, 1958) formed a hard crust of the surface mud of a drying fresh-water puddle. For another collection (Deg. & Deg. 24,572a, Feb. 2, 1958), see Scytonema hofmannii.

Microcoleus paludosus (Degener 21,341; reported in Bull. 41, p. 40, is a misidentification for M. chthonoplastes, mentioned above.

Microcoleus tenerrimus Gom. (Deg. & Deg. 24,595, Feb. 1, 1958). On the coral slabs cast up onto dry land by storm waves and there left to rest undisturbed for many months and even years, the dark Entophysalis deusta thrives, as described in detail under that species. Nearer the beach, however, are similar coral slabs, somewhat more often tumbled about by wave action and hence alabaster-white. Such flat stones, because of their coral origin, are translucent and of course more or less porous, the degree depending upon the precise species of animal. Due to the intensity and the drying effect of the sun, perhaps the upper nine-tenths or even more of the slab is relatively devoid of

plant life. But the remaining area, as in a greenhouse or fernery, supplies an environment of diffuse light and relatively constant moisture, particularly if lying on moist sea sand. For this reason it is a pleasant pale green. An occasional cuttle-bone, the inside shell of the cuttle-fish, lies among such coral. As it has the same general appearance, we suspected it to be a similar locus for the growth of Cyanophyta. Stone-like coral being difficult to handle, we sent the cuttle-bone to Dr. Drouet for dissection. Here he found Microcoleus tenerimus, Plectonema terebrans, Entophysalis deusta and some Calothrix crustacea.

Phormidium gardnerianum Dr. (Deg. & Deg. 24,592, Feb. 19, 1958), with Lyngbya aestuarii, colored spinach-green most of the bottom of a brackish pool on Spam Island.

Phormidium papyraceum (Ag.) Gom. (Deg. & Deg. 24,592, Feb. 19, 1958), associated with Nodularia sphaerocarpa and Plectonema nostocorum, was collected about a mile east of the Landing Strip, northern Canton. Here the Armed Forces during the Second World War had constructed a cement trough three by six feet in area and a few feet deep. This was permanently rain-filled and here P. papyraceum formed dark, paper-thin, blue green pellicles more or less attached to the trough sides. Among this well-named alga lived the bloodred larva of the midge Tendipes esakii, originally described from Saipan.

Porphyrosiphon fuscus Gom. (Deg. & Deg. 24,598a, Feb. 11, 1958), see Schizothrix lamyi.

Schizothrix creswellii Harv. (Deg. & Deg. 24,574, Feb. 8, 1958). Tridacna shells are everywhere; but the living mollusks, standing upright above the general surface of the water shallow at low tide, are rather localized. The shells are agape, exposing to the sun their voluminous mantles which are of strikingly beautiful pastel shades, almost gleaming in the sun. These vary from purples and dark browns to yellows, greens and blues. It is reliably reported that the unusual color of the mantle is caused by microscopic blue-green algae living in symbiotic, almost captive, relationship, with the tridacna. We killed no tridacna for samples of blue-greens; living tridacna we knew only from the ocean reef. Then Mr. & Mrs. Albert Lincoln brought us to an unusual stand of these living baptismal fonts, located in shallow water in the lagoon, about 16,000 feet east of the northwest end. Along the muddy bottom was a rusting pipe, its surface as though whitewashed. This encrustation was pale green with S. creswellii. The species (Deg. & Deg. 24,910, Feb. 1958) likewise impregnated a cuttle-bone lying dry on the beach.

Schizothrix heufleri Grun. (Deg. & Deg. 24,580, Feb. 11, 1958), with Scytonema hofmannii, grew in a drying, rain-filled depression one mile east of the north Landing Strip. It formed a thin mat over the sandy, cocoa-colored loam. Regarding another collection (Deg. & Deg. 24,600a, Feb. 10, 1958), see Nostoc calcicola.

Schizothrix lamyi Gom. (Deg. & Deg. 24,598, Feb. 11, 1958) grew one mile off the north Landing Strip with Porphyrosiphon fuscus and Entophysalis deusta in a drying depression once filled with rain water.

The tough, 1-2 mm. thick, greenish film was exfoliating due to shrinkage induced by drying, and curling upward and inward to expose the cocoa-colored underside and the now bare, similarly colored, exposed ground.

Schizothrix longiarticulata Gardn. (Deg. & Deg. 24,567, Jan. 31, 1958), with some Scytonema hofmannii, grew inland, namely near the ancient guano railroad wharf. It formed a firm covering over the brownish sun-baked loamy sand, but was beginning to crack here and there, and exfoliate. The same species (Deg. & Deg. 24,585a, Feb. 11, 1958), found with Calothrix crustacea, was about three miles east of the Landing Strip. Additional collections are Deg. & Deg. 24,596a, Feb. 11, 1958, with S. taylorii; and Deg. & Deg. 24,579a, Feb. 14, 1958, with Microcoleus acutissima.

Schizothrix taylorii Dr. (Deg. & Deg. 24,596, Feb. 11, 1958), along with S. longiarticulata and Scytonema hofmannii, was collected one mile east of the north Landing Strip. These plants covered the loamy bottom of a drying depression of rain water with a thin film. This acted as a dustbinder only until thorough drying caused the film to crack, curl and exfoliate. Another collection (Deg. & Deg. 24,582, Feb. 10, 1958), formed a greenish film over the cocoa-colored mud of a shallow arm of the lagoon, on the south side of the atoll.

Spirulina subsalsa Cerst. (Deg. & Deg. 24,753, Feb. 12, 1958) was brought from a depth of ten to fifteen feet for us in the lagoon by Mr. Albert Lincoln by skin diving.

Spirulina tenerrima Kütz. (Deg. & Deg. 24,785, Feb. 6, 1958) grew in association with Hydrocoleum lyngbyaceum Kütz., on a smooth, limestone, ocean reef along the north shore.

Sumploca hydroides Kütz. (Deg. & Deg. 24,750) was collected under similar circumstances as Spirulina subsalsa.

NOSTOCACEAE

Nodularia sphaerocarpa Born. & Flah. (Deg. & Deg. 24,599a, Feb. 11, 1958), see discussion of Phormidium papyraceum.

Nostoc calcicola Breb. (Deg. & Deg. 24,600, Feb. 10, 1958), in association with Schizothrix heufleri, grew near the ruins of the PAA hotel, south of Musick Light. Here we found a concrete platform, exposed to full sunlight. A few of the cement squares had tipped in settling, enabling a rain puddle to form. Here grew the above plants.

SCYTONEMATACEAE

Plectonema nostocorum Born. (Deg. & Deg. 24,599b, Feb. 11, 1958), see discussion of Phormidium papyraceum.

Plectonema terebrans Born. & Flah. (Deg. & Deg. 24,573c, Feb. 8, 1958), see discussion of Johannesbaptistia pellucida; for Deg. & Deg. 24,595a, Feb. 1, 1958, see treatment of Microcoleus tenerrimus.

Scytonema hofmannii Ag. (Deg. & Deg. 24,572, Feb. 2, 1958) is probably the most persistent sand-binder on Canton, and fortunately common. It is to be seen about the CAA residential area along and even on the white roads, where pincushion-like tufts of Fimbristylis pycnocephala and the more open F. dichotoma grow. Omitting the larger projecting pebbles, gleaming white in contrast, it covers the surface of the ground with an almost black matrix. When we drew the attention of several residents to these Scytonema areas over which they had been walking day after day, they were astounded to learn that what they had always considered a tar-rich asphalt was actually a colony of "seaweed or limu." With the Scytonema grew some Microcoleus chthonoplastes. These areas in February were alternately sun-scorched and rain-drenched. Additional collections of this species are Deg. & Deg. 24,567a, Jan. 31, 1958, with Schizothrix longiarticulata; Deg. & Deg. 24,580a, Feb. 11, 1958, with Schizothrix heufleri; and Deg. & Deg. 24,596b, Feb. 11, 1958, with Schizothrix taylorii.

RIVULARIACEAE

Calothrix crustaceae Thur. (Deg. & Deg. 24,585, Feb. 11, 1958), with Schizothrix longiarticulata and the almost ubiquitous Entophysalis deusta, was loosely holding the white, muddy sand in a drying depression three miles east of the north Landing Strip. It (Deg. & Deg. 24,581a, Feb. 15, 1958) grew with the same E. deusta in a drying fresh water puddle one mile west of Shark Pool, southeast tip of Canton. For specimen Deg. & Deg. 24,595c, Feb. 1, 1958, see discussion of Microcoleus tenerimus.

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Lichens, mosses and ferns have not been found on Canton.

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by

E. Yale Dawson

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E. Yale Dawson

The following annotated list has resulted from an examination of a collection of algae made during the first part of February, 1958, by Dr. and Mrs. Otto Degener on Canton Atoll in the Phoenix group. Only the green, brown, and red algae are treated here, inasmuch as a rather large series of Cyanophyta has been identified by Dr. Francis Drouet and is accounted in Bulletin No. 64.

With the exception of about a dozen species mentioned by Degener & Gillaspy (1955) on the basis of determinations by M. S. Doty, this is the first floristic list of which I am aware of the marine vegetation of Canton Atoll, or of any island in the Phoenix group. Accordingly, these records supplement and extend our knowledge of central Pacific atoll floras derived from such reports as have appeared in recent years for the Marshall, Gilbert, and Line Islands (cf. Taylor 1950, Dawson, Aleem & Halstead 1955, Dawson 1956, 1957, Moul 1957).

The specimens are cited according to Degener collection numbers. The first set of specimens, all of which are liquid preserved, has been deposited in the Herbarium of the University of California, Berkeley.

CHLOROPHYTA

Enteromorpha clathrata (Roth) J. Ag. 24841.

Enteromorpha sp. 24863. This appears to agree with what Chapman has called E. clathrata var. pumila (Aresch.) Chapm. from New Zealand.

Enteromorpha kylinii Bliding 24763; 24764; 24739; 24849?

Ulvella lens Crouan 24843a, growing on Caulerpa serrulata.

Cladophora fascicularis (Mert) Kütz. 24717. This material, about $1\frac{1}{2}$ cm. tall, is in good agreement with Borgesen's illustrations of specimens both from Mauritius and the West Indies. The specimens are much smaller in height than many West Indian ones, but agree in cell size and form.

Cladophora flexuosa (Griffiths) Harv. 24852. The specimens show such close accord in size, habit, branching and cell form with this tropical Atlantic species as to be referable here with reasonable certainty. The similarity to Vicker's illustration of the species from Barbados is especially striking. The plant is reported from Australia, but apparently not from the central Pacific.

1. Contribution from the Beaudette Foundation for Biological Research, Solvang, California.

Dictyosphaeria cavernosa (Forrsk.) Börg. 24724; 24735; 24832;
24839; 24865.

Boodlea composita (Harv.) Brand 24716b; 24719. The latter specimen represents a lax form and bears much sterile Ceramium gracillimum v. byssoides.

Cladophoropsis gracillimum Dawson 24758. These are in good agreement in structure, but are slightly coarser than either the Mexican type or material from Arno Atoll, Marshall Islands, and much coarser than Eniwetok material. The colony is quite compact and the filaments densely arranged in a rather erect fashion. The exceedingly long cells and thick, stratified walls are distinctive. Number 24781 is still coarser, up to 140 μ in diameter in some places, although mostly about 125 μ . Some of the walls are up to 20 μ thick. This would seem to be a particularly robust form of this generally slender species.

Cladophoropsis sundanensis Reinbold 24715. This is very much like material from Palmyra Island, forming rounded, compact colonies as reported from there. The filaments are about the same size or tending to be slightly larger. 24826a, growing in a turf with Jania tenella, has filaments 70-100 μ in diameter. 24747 is a very young colony compacted with Lyngbya filaments. 24766 shows the characteristic sub-spherical clumps, but the cells are very long. 24820 has filaments 100-130 μ in diameter. 24846 is a darker colored form with somewhat shorter cells than other material from this area. It may be a distinct entity, but points of distinction are not clear.

Derbesia attenuata Dawson 24572a. Well developed, typical material, on Turbinaria.

Caulerpa racemosa var. peltata (Lamx.) Eubank 24713; 24716;
24756a; 24787; 24831; 24845; 24861; 24864.

Caulerpa racemosa var. turbinata (J. Ag.) Eubank 24784.

Caulerpa serrulata (Forrsk.) J. Ag. emend. Börg. 24751; 24756;
24782; 24843.

Caulerpa urvilleana Mont. var. 24840; 24842.

Bryopsis pennata Lamx. 24731; 24743 (On Turbinaria); 24822a;
24837; 24850. Unilateral branching is especially prominent and consistent in this last collection.

The following identifications and notes on Codium are provided by Dr. Paul C. Silva, University of Illinois.

Codium ovale Zanard. 24746; 24740. This latter collection is a mixture of two species growing in intimate association: Codium ovale and a member of the C. arabicum complex. The known range of C. ovale has now been extended beyond the type locality

(New Guinea) to include Kwajalein, Majuro and Canton islands. The adherent Codium is somewhat more cerebriiform than is usual for C. arabicum, but anatomically it clearly reveals its relationship to the C. arabicum complex.

Codium geppii O. C. Schmidt 24714; 24570; 24788; 24821; 24851; 24825. These are very similar to the type collection. In the Indo-Pacific region a member of the C. arabicum complex and one of the C. geppii complex are always found as an integral part of the biocoenosis of coral reefs. In the Atlantic a similar, but less constant, relationship holds: an adherent form, referable to the C. intertextum complex, is invariably present on coral reefs, while a repent form, referable to the C. repens complex, is found only on certain islands.

Halimeda fragilis Taylor 24774.

Halimeda micronesica Yamada 24768. A good specimen 6-7 cm. tall.

Halimeda opuntia (L.) Lamx. 24771.

PHAEOPHYTA

Ectocarpus indicus Sonder 24836. Good material on Turbinaria with very long plurilocular sporangia often to 200 μ or more.

Sphacelaria furcigera Kütz. 24754 (on old Turbinaria); 24752b.

Sphacelaria sp. 24723a. This may be a tropical form of S. subfusca Setch. & Gard. The specimens have propagulae like S. furcigera, but many of them are trifurcate rather than bifurcate. Plurilocular sporangia, however, are dominant on this material.

Dictyota friabilis Setchell 24845a; 24828; 24859; 24862; 24868. This latter collection is almost without doubt like the type from Tahiti.

Dictyopteris repens (Okam) Börg. 24752 (small amount).

Pocockiella papenfussii Taylor 24824.

Pocockiella variegata (Lamx.) Papenf. 24765.

Turbinaria ornata (Turn.) J. Ag. 24783.

Turbinaria trialata (J. Ag.) Kütz. 24721.

RHODOPHYTA

Gelidium pusillum (Stackh.) Le Jolis 24736. Typical, small, cystocarpic material 3-4 mm. tall.

Pterocladia sp. 24742; 24755. These tetrasporic and cystocarpic materials are well developed, over 2 cm. tall, and pinnately branched much as in Pterocladia nana Okam. from southern Japan and Formosa. They may be referred provisionally to that species, but additional Pterocladia collections from the central Pacific, such as at Palmyra Island where one is reported from intestinal contents of fishes (Dawson, Aleem and Halstead, 1955) are needed to enable us to interpret more satisfactorily the occurrence of this genus.

Gelidiella rigidiuscula (Grunow) J. Feldmann 24737. This richly fertile material has the stichidia and branching much as in G. acerosa, but is smaller in size: 300 μ down to 120 μ in the ultimate branchlets. This is in agreement with the discussion and key in Feldmann (1931) of G. rigidiusculum from Ceylon, for which reproduction is not reported. The size and habit are much like G. hancockii from the Gulf of California, but that species has cylindrical tetrasporangial stichidia on short lateral branchlets rather than acute, bulbous, terminal ones as in the present material. This disposition seems justified awaiting the report of fertile material from Ceylon for comparison. 24838 (with some Herposiphonia secunda); 24759 (tetrasporangial); 24832a (some growing with Dictyosphaeria); 24789. The tetrasporangial stichidia in this collection are so abundant as to terminate almost every branch.

Gelidiopsis intricata (C. Ag.) Vickers 24728; 24857a.

Jania capillacea Harv. 24857.

Jania micrarthrodia Lemx. 24761a (cystocarpic); 24737a (with Gelidiella rigidiuscula); 24860.

Jania tenella Kütz. 24826 (in mixture); 24822 (a questionable form with very abundant conceptacles).

Erynea esperi Bory? 24730; 24854. These specimens have the tetrasporangial sori in part at first unilateral on the branches, causing some distortion. Later they may fill in all around. They are similar in this character to specimens reported and illustrated by Setchell as H. nidifica J. Ag. from Tahiti.

Gracilaria sp. 24866. This may be the plant described as Corallopsis reptans Weber van Rosse, from the Kei Islands.

Lomentaria sp. 24864b.

Ceramium clarionensis Setch. & Gard. 24730b.

Ceramium equisetoides Dawson 24864a. These are in good agreement with Pacific Mexican specimens.

Ceramium gracillimum var. byssoides (Harv.) G. Mazoyer 24716a; 24734a (with Caulerpa racemosa v. turbinata); 24730a (a very lax form); 24800; 24801b.

Ceramium vagabunde Dawson 24843c. This material is somewhat more slender than Eniwetok specimens and has nodal bands more like those of the material reported from Isla San Benedicto, Mexico, yet the agreement is generally satisfactory. Growing with Caulerpa serrulata.

Ceramium sp. 24840a. Fertile, tetrasporangial material apparently near C. personatum Setch. & Gard. The agreement is good except that the descending appendages within the axial cells were not observed. The tetrasporangia are at first abaxial, then whorled and involucrate. Growing with Caulerpa urvilleana.

Griffithsia sp. 24864c, sterile.

Herposiphonia secunda (Ag.) Ambronn 24733 (richly developed); 24805; 24829 (richly developed); 24834.

Heterosiphonia wurdemannii var. laxa Borg. 24748 (mixed with Herposiphonia); 24741 (in mixture); 24854a (on old Turbinaria); 24853.

The following determinations and notes on Polysiphonia are provided by Dr. George J. Hollenberg of the University of Redlands, California

Polysiphonia ferulacea Suhr 24866a. This determination is probably correct if Tseng, Cribb and others have been correct in their identifications of Pacific specimens. It should be considered tentative, however, until male plants are found.

Polysiphonia flaccidissima Hollenberg 24867. This determination is probably reliable although the segments are shorter (1.0-1.5 diameters) and the trichoblasts are not well developed and with tapering tips.

Polysiphonia mollis Hook. & Harv. ?? 24823. This identification is doubtful because of (1) small size; (2) obvious sympodial branching; (3) very long, continuous tetrasporangial branches.

Laurencia nana Howe 24761. The cortical cells are of the non-palisade type, although an error occurs in expressing this in Dawson 1957, p. 124.

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Notes on the geography and natural history of Wake Island

by

E. H. Bryan, Jr.

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Notes on the geography and natural history of Wake Island

by

E. H. Bryan, Jr.^{1/}

Wake is a V-shaped atoll in the northwestern Pacific, north of the Marshall Islands, between Midway and Guam. Its direction and distance are:

	Direction	Nautical Miles	Statute Miles
Wake to Midway	N. 60°E.	1029	1185
Wake to Honolulu	N. 85°E.	2004	2308
Wake to Guam	N. 75°W.	1309	1508
Wake to Tokyo	N. 55°W.	1723	1985

Wake Atoll consists of three islets, Wake islet, the largest, on the southeast, has the shape of a V, the arms of which are about two and three quarters land miles long. Each arm is continued, beyond a narrow lagoon entrance, as a separate islet, Peale islet on the north and Wilkes islet on the south. The western ends of these two islets are connected by a sweep of flat reef, which continues as a narrow border along the ocean side of all three islets. In 1923, the enclosed rectangular lagoon had depths up to fifteen feet. The following is a summary of the land and salt water areas of the atoll:

	Area: Square land miles	Acres
Wilkes (named for Charles Wilkes, USN)	0.31	197.44
Wake (named for William Wake)	2.14	1,367.04
Peale (named for Titian Peale, artist)	0.40	256.83
Total land area	2.85	1,821.31

Area of enclosed lagoon (water and sand flat) 3.75 Square land miles

The names of the two smaller islands were given by Dr. Alexander Wetmore and other members of the U.S.S. Tanager Expedition on July 27, 1923. Lieutenant (later Commodore) Charles Wilkes was the leader of the United States Exploring Expedition, which visited and mapped the atoll, December 20, 1841; Titian Peale was the artist and one of the naturalists on this same expedition.

^{1/} Curator of Collections, B. P. Bishop Museum, Honolulu 17, Hawaii.

This compilation from various notes in the author's geographic files was prepared in August 1957, so that the information could be made available to persons living on or visiting Wake. Portions are taken direct from the author's book, "American Polynesia and the Hawaiian Chain," Honolulu 1942, chapter 57, pages 208 to 214.

This atoll also has been known as Halcyon or Helsing, and some authorities think it may have been the same as San Francisco Island, discovered by the Spanish explorer, Mendana, October 4, 1568. The official discovery, however, is credited to Captain William Wake, in the British schooner Prince William Henry, in 1796. The island was seen in 1823 by Captain Gardner from the whale ship Bellona. He described it as being 20 to 25 miles long [quite an exaggeration], with a reef extending two miles from the east end, with detached rocks on the west [probably those on the curving reef]. He noted that it appeared well covered with trees. It was also seen by Captain James Hunnewell from the Mentor, December 20, 1824. Halcyon Island was said by Captain Kotzebue to have been an American discovery, located at about 19° 23' N., 165° 33' E. After unsuccessful search for it by Captain Sproule of the barque Maria, by Captain Brown in the Morning Star, and by the U.S. Exploring Expedition, the conclusion was reached that Halcyon was the same as Wake. Captain F. W. Beechey, R.N., in H.B.M. ship Blossom, tried to locate Wake Island in March 1827, without success.

The United States Exploring Expedition, under Charles Wilkes, visited and mapped Wake in December 1841. Wilkes' "Narrative" (V: 284-5, 1844) reads:-

"Wake's Island next claimed my attention. On the 19th we reached its parallel, and hove-to till daylight of the 20th, when we discovered it, bearing west-by-north, about nine miles distant. The wind was light from the north-northeast. After breakfast, several boats were sent to survey the island. Wake's Island is a low coral one, of triangular form, and eight feet above the surface. It has a large lagoon in the center, which was well filled with fish of a variety of species; among these were some fine mullet. There is no fresh water on the island, and neither pandanus nor cocoa-nut trees. It has upon it the shrubs which are usually found on the low islands of the Pacific, the most abundant of which was the Tournefortia. Mr. Peale found here the short-tailed albatross, and procured an egg from its nest. The birds were quite tame, although they were not so numerous as we had before met with on uninhabited islands.

"The time of low water took place at one o'clock, and the moon entered its last quarter on the same day: the tide was setting along the shore of the island with much strength to the westward; the rise and fall was three feet. From appearances, the island must be at times submerged, or the sea makes a complete breach over it; the appearance of the coral blocks and of all the vegetation leads to this conclusion, for they have a very decided inclination to the eastward, showing also that the violent winds or rush of the water, when the island is covered, are from the westward. The reef around this island is very small in extent.

"The position of Wake's Island was found by my observations of equal altitudes on shore to be in longitude 166° 31' 30" E., and latitude 19° 10' 54" N."

"By four o'clock, P.M., all the boats had returned on board, when we filled away and proceeded on our course to the westward. Although these coral islands resemble one another very strongly, yet they afforded us some recreation for a few hours, and much satisfaction in obtaining

series of observations in magnetism. Our visit to Wake's Island gave us an opportunity of adding to our collections in natural history.

"In the evening we steered to pass over the position of Halcyon Island,- longitude 163° 30' E., latitude 19° 13' N.; and on the 27th, we passed immediately over its locality, and had run on its supposed parallel fifty miles on each side of it, but nothing was seen of it. We now felt the current to the southeast 12' in the twenty-four hours."

Following the careful mapping of the island by Wilkes in 1841, several vessels are recorded as having sighted Wake, including the barque Maria, under Captain Sproule, in 1858; as noted by Dr. William T. Brigham, Wake was seen also "from the masthead of the ship Oracle in 1865."

On March 4, 1866, the Bremen barque Libelle, under command of Captain Tobias, went ashore on the east reef. On board were several prominent passengers and a cargo valued at over \$300,000. Among the passengers were Madame Anna Bishop, Miss Phelan, M. Schultz and Charles Lascelles, of an English opera troupe, a Japanese traveller named Kisaboro, and Eugene M. Van Reed, whose account of the experience appears in the Friend [Honolulu] for September, 1866. Following a hazardous night on the ship, during which waves broke over the vessel, passengers and crew were landed the following day with great difficulty through the breakers. After three weeks on the island, without finding source of food or water, it was decided to try to reach the Mariana Islands in open boats. On March 27 they set out, passengers in the 22-foot longboat, twenty-two persons under command of the First Mate, and the Captain and remainder of the crew in the gig, with what provisions and water they were able to salvage. After thirteen days of frequent squalls, short rations, and tropical sun, the longboat reached Guam. The Captain with eight persons, in the twenty foot gig, were not heard of again, although a schooner from Guam went in search. The passengers were strong in their praise of the courtesies received from Francisco Moscoso y Lara, Governor of the Marianas.

Several vessels went to Wake to salvage the cargo, which included several hundred flasks of quicksilver. The sloop Hokulele, with a party headed by T. R. Foster, left Honolulu May 9, 1867, reached Wake on May 31st, left there June 22, and returned to Honolulu July 29, with 247 flasks of quicksilver. A brig from China salvaged another 248 flasks at about the same time. Thomas Foster, Captain English, and eight Hawaiian divers landed at Wake from the Hawaiian schooner Moi Wahine in September 1867. Three days after their arrival their schooner, with Captain Zenas Bent in command, mate Wight, and a crew of five, was driven to sea by a gale and not heard of again. The salvage party was rescued by the English brig, Cleo, Captain Cargell, in March 1868, and returned to Honolulu on April 29, with 240 flasks of quicksilver, some copper, anchor and chain.

In 1883 the German warship Leipzig passed close to Wake and a careful determination of its position was made.

During the Spanish-American war, several vessels going to and returning from the Philippines stopped and raised the American flag. One of these visits, perhaps the earliest, was on July 4, 1898, by

General F. V. Green, commanding the second detachment of the Philippine expedition, from the S. S. China. Another, also in July 1898, was by General Merritt, from the U. S. Army Transport Thomas. This landing probably was made in the little cove near the eastern end of Wilkes islet, for on August 2, 1923, just inland from the landing place, the writer found a section of flagpole, about 18 or 20 feet long, on which was burned in block letters, "U.S.A.T. Thomas."

The formal annexation of the island by the United States took place on January 17, 1899, according to an account by Commander Edward D. Taussig in the U.S. Naval Institute Proceedings for June 1935. He commanded the U.S.S. Bennington which made the voyage from Honolulu to Wake for that purpose. The landing was made in the cove noted above, and at 3:22 P.M. the American flag was hoisted by Ensign Wettengell and a salute of 21 guns fired from the Bennington. The position of the flagstaff was determined, from observations on the ship, to be: 19° 17' 50" North, 166° 31' East. The account continues:

"After the salute was fired the flag was nailed to the masthead with batten, and a brass plate with the following inscription was screwed near the base of the flagstaff:

United States of America
William McKinley, President;
John D. Long, Secretary of the Navy,
Commander Edward D. Taussig, U.S.N.,
Commanding U.S.S. Bennington,
this 17th day of January, 1899, took
possession of the Atoll known as Wake
Island for the United States of America."

During the next decade an occasional American ship stopped, but there is very little recorded history. During this time the island was visited by Japanese poachers, collecting the feathers of sea birds for millinery purposes. Two camps were established: one on the eastern end of Wilkes islet, where the Tanager Expedition in 1923 found a single wooden shack and a grave; and one across the lagoon near the eastern end of Peale islet, where there was a more extensive camp. This is described in the writer's field notes for July 31, 1923, as follows:

"The camp consists of the remains of two large frame buildings with galvanized iron roofs, about 18 feet wide, one 20 feet long, one 30 feet long; two smaller buildings; one tank, and one storehouse, raised on posts which are guarded with tin. Scattered about were a number of barrels, boxes, two large clay water jars, tin cans and metal kettles. Saw part of a Sydney newspaper, a pile of oakum, bamboo frame with lath trays. There was also a boat, a little larger than a skiff. Made a copy of a Japanese inscription inside the bunk house." Later this was translated to read something about leaving the island, with the date, November 13, 1908.

In 1912, the U.S.S. Supply stopped at Wake Island. A whaleboat landed some men who planted coconut palms brought there from Guam. No sign of these was seen in 1923.

The Tanager Expedition made an extensive biological survey of Wake from July 27 to August 5, 1923. Their camp was along the ocean beach opposite the landing place at the eastern end of Wilkes islet. A map of the atoll was made by James B. Mann and Professor Harold S. Palmer, to which the writer added determinations of latitude and longitude, made from a boulder near the camp. Meanwhile soundings were made around the island from the U.S.S. Tanager, under command of Lt. Cmdr. Samuel Wilder King, later Delegate to Congress and Governor of Hawaii. Although the vessel worked as near the reef as it dared, at only one spot was it possible to reach bottom with 100 fathoms of line; this was about 1500 feet off Heel Point, where a sounding of 85 fathoms was made.

A total of 19 species of flowering plants was found growing naturally on Wake. Much of the surface of all three islets was found covered by scrub forest, 12 to 20 feet high. Some of the forest was so dense that one could not walk through it with speed or comfort. Other places, such as the middle portion of the northeastern arm of Wake and the western ends of Wilkes and Peale, there were areas where the trees were low and scattered, with rocky surface and scrubby undergrowth, as if here the sea broke across the rim at time of storms.

The dominant tree on the islands was the Tournefortia or tree heliotrope, also known to scientists as Messerschmidia argentea, a species widespread on Pacific Islands. It grows to a height of about 20 feet, with an umbrella-shaped canopy of rosettes of large leaves, covered with silvery hairs. Even larger in size, but confined to the northwestern end of Wake islet was the "byka" tree (so-called by Gilbert islanders), Pisonia grandis, with massive trunks of very soft wood and sticky flowers and fruit. On Wilkes islet, and apparently spreading rapidly along the lagoon beach of Wake, to the east and north, were tall wiry bushes of Pemphis acidula. In the interior of Wake were small clumps of kou trees (so-called in Hawaii), Cordia subcordata, a hard wood tree, much prized in some regions for woodwork, but here scrubby and worthless. Growing over trees, rocks and bushes, and forming tangles on the ground, was a morning-glory vine, Ipomoea tuba, formerly called Ipomoea grandiflora. The plants observed in 1923 have been listed by Christophersen (1931).

The bird life on Wake consisted of about a dozen species of sea birds, half a dozen migratory species, and the flightless rail, Rallus wakensis, the only native land bird. The only mammal was the Polynesian rat, Rattus exulans. Of reptiles there were two kinds of geckos and two kinds of skinks, to be described later. A number of species of insects were collected and many kinds of marine life, both fishes and invertebrates.

To those of us who camped on Wake in 1923, as much a pest as the rats were the hermit crabs. One large, red-legged species, Dradanus punctulatus, got into our provisions, ran off with our soap, and combined the activities of pack rats with those of being the garbage department of the island.

In 1935 Wake Island was placed under jurisdiction of the United States Navy Department by Executive Order. That same year Pan American

Airways established a modern airport, using the south shore of Peale islet, just west of Flipper Point, as the site of pier, shops, water tanks, and a modern hotel.

Then the threat of war descended on Wake. On February 14, 1941, President Franklin D. Roosevelt signed an Executive Order making the island a national defense area.

The military importance of Wake Island led to great activity on the part of the United States to fortify the island during 1940 and 1941. The defense force was small and although gallant, not equipped to defend the island against overwhelmingly superior numbers.

It is not an object of this account of the natural history of Wake to expand upon the World War II's history of the island. That has been done by Major James P. S. Devereux, the commanding officer of the Marine forces (1947), by R. D. Heinl, Jr., in the official Marine account of the defense of Wake (1947), by Rodney Kaphart (1950), and D. C. Woodbury (1946). There is also a brief official Naval release in the *Paradise of the Pacific* for February 1942 [pages 10 to 12].

The air attack began on December 8, 1941 and continued for several days as wave after wave of Japanese planes bombed the little island. The end is told in a historical marker, set up following the war on the south shore of Wake islet:-

"In this area occurred the principal fighting which led to the island's surrender. About 1000 Japs were landed between 0120 and 0430, 23 Dec. 1941. They were opposed by 85 U.S. Marines who fought ferociously and valiantly until 0030 in the best traditions of their corps until ordered by their superiors to surrender to save American life because the situation was hopeless. Marine forces were composed of portions of the First Marine Defense Battalion under Major Devereux and Marine Fighting Squadron 211, under Major Putnam."

The Japanese renamed Wake "Otori" and held the island until the end of the war, surrendering to an American force September 7, 1945. The capture achieved very little for the Japanese. The island was bombed repeatedly by American forces and its isolation made it difficult to supply. The garrison, at times numbering more than 4,000 Japanese, suffered great privation from lack of food and water.

Mute evidence of the Japanese efforts to fortify Wake, and the American work of destruction is to be seen everywhere on the island. Pathetic little garden plots tell their own story of starvation. Wrecks of Japanese vessels dot the beaches.

One of the blackest and saddest paragraphs in the whole war story has to do with the fate of the 98 American civilians, who could not be evacuated by the Japanese. They were marched to the beach, and

there cruelly slaughtered by command of Admiral Sakaibara, who after the war was tried and hanged for this act.

Wake Island came into the limelight in October 1950, when it was the meeting place for President Truman and General Douglas MacArthur, in their discussion of the Korean situation.

Another event, which will long be remembered by the 550 persons who were on Wake, was typhoon Olive which hit the island in September 1952. It cost some \$1,600,000 to rebuild installations destroyed or damaged by this tropical storm.

At present (1957) Wake Island is in the charge of the Civil Aeronautics Administration, which maintains and controls the airport and runway.

Four short visits were made to Wake by F. R. Fosberg during which he made collections, principally of plants, and observations on the vegetation and on the general ecology of the atoll. These were, in order, on October 23, 1951, April 19-21, 1952, July 18, 1952 and October 22-23, 1953. His observations on birds and other vertebrate animals, with a section on pest control, have been incorporated into the present article. For his account of the vegetation and flora see the separate article by him immediately following this one.

Notes on rats and pest control on Wake Island, 1952.--Contributed by
F. R. Fosberg

On a brief visit in October, 1951, rats were noticed in the Pan American Airways dining hall, but no particular attention was paid to them. They were at that time or somewhat earlier, said to be so numerous that they bothered the Pan American plane crewmen sleeping in the hotel.

In April, 1952, two days were spent on Wake, much of the time in the field with Fred Schultz, at that time in charge of pest control for the Civil Aeronautics Administration on the island.

During the previous year Mr. Schultz had waged an extremely successful campaign against rats on the island. He started by studying the habits of the rats rather carefully. He found that they lived largely in the clumps of bushes, especially those which were covered by tangles of the wild white morning glory, Ipomoea tuba. He found that they utilized the enlarged immature fruiting calyces of this species in lieu of a water supply. He said there were four kinds of rats on the island.

In the two days of actively looking for rats, along with other animals and plants, only one rat was seen, this a large blackish one.

Schultz had for many months carried out an active poisoning program, using Warfarin in rolled oats, placed in small quonset-hut-like shelters about a foot long, and renewed frequently. These Mr. Schultz strung in two series of lines across the center of the island from lagoon to outer shore a short distance apart. These were visited

every day, examined, the bait renewed, till the baits were not disturbed much any more. Then the series of lines were moved a little farther apart. This was continued until the entire atoll had been covered, and the rats greatly reduced. After this a few lines were maintained, scattered at intervals over the islands, and visited and the bait renewed once a week. As long as less than 10% of the baits were disturbed the rats were considered controlled.

Flies and mosquitoes were also the special objects of Mr. Schlutz' efforts. At the beginning of 1951 there were untold numbers of these insects on Wake Island. Garbage and other fly breeding material was eliminated. Garbage dumps were regularly burned and buried. Old tires, cans, and other breeding places for mosquitoes were systematically drained and punctured, and larger bodies of water, such as ponds, bomb craters, and cisterns were stocked with mosquito fish. Three species of mosquitoes had been known from the island, Culex quinquefasciatus, Aedes aegypti, and another Aedes, possibly A. scutellaris or A. albopunctata.

The success of these measures may be judged by the fact that in two and a half days spent in covering the island, mostly in company with Mr. Schultz, only one rat, no mosquitoes, and a very few flies were seen. In his weekly examinations of his poisoned baits at this time he commonly found less than 5% of them touched by rats.

LAND AND FRESHWATER VERTEBRATES

MAMMALS

In 1952 domestic dogs and cats were seen by F. R. Fosberg, but none were specifically noted in 1953.

Although Mr. Fred Schultz stated that prior to his activities, described above, there were four species of rats on Wake, a check by Dr. D. H. Johnson of the collections at the U. S. National Museum shows that only Rattus exulans Peale is represented by specimens from this island. He suggests that the others noted by Mr. Schultz were probably forms of Rattus rattus, the common house rat, though it is possible that Rattus norvegicus, the Norway rat, could have established itself there also. A series of skins and skulls collected to represent the rat populations living on the island would be very desirable to settle this question.

BIRDS

Now that the Wake Island rail is gone, only sea and migratory birds are found on Wake Island. Dr. Alexander Wetmore made a careful survey of the birds of Wake during July and August 1923, but no detailed report resulted. The rail was present at that time. In 1940, the writer prepared a list of the birds likely to be seen on Wake for Torrey Lyons, who was working on the island, but this was made from memory and notes, without an actual survey. In 1952, Dixon and

Starrett reported various birds seen at sea near Wake during 1945 and 1946. Writing in the *Elepaio* for January 1953, H. Paul Porter praised "the brave young birds of Wake Island," on their ability to ride out a typhoon which left some ten million dollars damage in its wake; but he mentioned only "terns."

The only detailed recent account of the birds which I have seen gives a rather discouraging picture of what the war left on the island. Dr. Alfred M. Bailey, "Notes on the birds of Midway and Wake Islands," 1951, says: that the main island is nearly devoid of bird life, other than a few sea and migratory species. Wake rails had not been seen since the island was reoccupied by Americans. He quotes from the diary of a Japanese officer regarding daily bombing by American planes.

"An order has just come out," states the diary, "forbidding us to catch gooney birds [albatrosses] lest they be wiped out." Dr. Bailey continues:

"The effort of this officer to protect the 'gooney birds' must have been largely in vain. Most of the birds were destroyed by the starving soldiers, although a great colony of sooty terns (Sterna fuscata) was guarded so that the eggs could be gathered regularly. The sooty tern colony on Peale Island ... was the largest I had ever seen. On May 15 [1949] I saw thousands of birds on their eggs. The downy young were beginning to hatch on that date.

"A few man-o'-war-birds (Fregata magnificens) were sitting about on the rusted iron skeletons of bombed naval buildings. Small groups of noddy terns (Anous stolidus) were nesting in the dwarfed trees known locally as bukas (Pisonia grandis). I saw two white-tailed tropic-birds. It was apparent that the bird population had suffered from the Japanese occupation, for aside from what I have just mentioned, there were no birds. We did not see any boobies (Sula), red-tailed tropic-birds, or albatrosses. A search for such burrow-nesting birds as petrels and shearwaters was out of the question, for my time was so short. I saw nothing of either."

Despite this discouraging statement, I venture to repeat my list of birds which might be expected to occur on Wake, with brief description of each:-

Family DIOMEDEIDAE, albatrosses

Diomedea immutabilis Rothschild, the Laysan Island albatross*, and Diomedea nigripes Audubon, the black-footed albatross, might possibly stray as far as Wake from their regular area between the N. W. Hawaiian and Bonin Islands.

Family PROCELLARIIDAE, petrels and shearwaters

Puffinus pacificus chlororhynchus Lesson, the wedge-tailed shearwater, is the most likely member of this group; 17-19 inches long, it is a large shearwater, with long, wedge-shaped tail; upper parts sooty brown, crown neck and wings darker, forehead paler; under parts paler than upper, some bellies quite white.

*One can be seen in front of hotel in post-war photo (Kaucher, 1947).

Pterodroma hypoleuca hypoleuca Salvin, stout-billed gadfly petrel or Bonin Island petrel; 12-14 inches long; upper parts grayish, deep slate on forehead, margined with white; under parts white except sides of breast sooty black.

Family PHAETONIDAE, tropic birds

Phaethon rubricauda rothschildi (Mathews), red-tailed tropic bird; 18 inches long; including long, slender tail feather, black shaft, bright red webs; plumage silky white, some tinged with rose; a few black spots, especially in young. Nest a hollow in sand, secluded beneath a bush, bunchgrass, or slab of rock.

Family SULIDAE, boobies and gannets

Sula sula rubripes Gould, red-footed booby; 23-28 inches long; adult white, head and neck tinged buffy, wings with hoary-gray markings; tail white; feet red. Young: sooty-brown above; head, back and lower parts smoky-gray; recognized by red feet. Nests in any available bush or tree, almost never on ground; lays a single egg in a crude platform of leaves and twigs. One seen returning to the island just before sunset, on July 18, 1953, by Fosberg.

Sula leucogaster plotus (Forster), brown or brown-vested booby; 30-31 inches long. Adult head, neck, back, wings and upper breast deep sooty brown; all white below. Young: brownish-gray, upper parts darker than lower. Builds nest of twigs on ground or low scrub; lays two bluish-white, chalky eggs. In 1953 Fosberg saw a number of brown boobies flying on Peale Islet. In April 1952 boobies were seen on Peale Islet, nesting in trees, but the species was not determined with certainty.

Sula dactylatra personata Gould, masked or blue-faced booby; 25-29 inches long. Adult: white, with wing-coverts, primaries, secondaries and most of tail sooty-brown; mask bluish or olive, legs and feet deep brown. Young: upper parts grayish-brown, white below. Lays two limy-white eggs on bare sand. In 1953 Fosberg saw a very few blue-faced boobies on Peale Islet.

Family FREGATIDAE, frigate or man-o'-war birds

Fregata minor (Gmelin), Pacific man-o'-war bird. Adult male: large, blackish, with forked tail; head and back glossy purple; breast lighter than belly; large red patch under chin which inflates like a child's balloon. Female like male but head blacker, chin and throat grayer, breast whiter. Exact subspecies is uncertain; could be minor of western Pacific and Indian Ocean, or palmerstoni of Hawaii. Nestling is fluffy, white "puff-ball;" becomes rufous or cinnamon before becoming black adult. Both parents sit on nest, which is large pile of sticks. Obtains fish by harassing other birds, especially boobies, in air. In 1952 many frigate birds were seen by Fosberg, mostly roosting on the remains of an old pier on Peale Islet. In 1953 there were many more, hundreds of them, flying or roosting on an old steel frame or on power lines.

Family RALLIDAE, rails, gallinules, coots

Rallus wakensis (Rothschild), the Wake Island rail; 9 inches long; upper parts dark ashy brown, chin and upper throat whitish, neck gray, under parts ashy brown, barred with white. Wings about 4 inches long and so soft as to suggest little power of flight. Endemic to Wake [See Mayr, 1945]. Believed to be extinct.

Family CHARADRIDAE, plover

Pluvialis dominica fulva (Gmelin), Pacific golden plover; 10 inches long; summer adult: mottled black above with golden and ashy; dull dusky black beneath; whitish frontal band and eyebrow. Winter adult (plumage most likely to be seen): without black on under parts, whitish on throat and belly; light brown, streaked with gray, elsewhere. No hind toe. Arrives from north in fall; flies north in spring. Breeds in northern Asia and Alaska. On April 20, 1952, only two plovers were seen by Fosberg, but he was informed by Mr. Fred Schultz that there were many of them only a day earlier. In October, 1953, several dozen plovers were seen feeding in ponds, and a few scattered elsewhere.

Family SCOLOPACIDAE, snipe, sandpiper

Numenius tahitiensis (Gmelin), bristle-thighed curlew. Length 17 inches; bill 3- inches. Dusky brown above, varied with buff; tail ochraceous, barred dark brown; dull buff beneath; cheeks, neck, chest with brown markings; thighs with bristle-like points. Migratory species.

Heteroscelus incanus (Gmelin), wandering tattler; 10-12 inches long; olive-gray above, white below and on throat and chin; lower parts streaked and barred with dusky in summer (when arrive from north also), but soon molt and lose this. Feeds close to the beaches on small marine creatures. One tattler was seen by Fosberg in April, 1952, and one in October, 1953.

Arenaria interpres (Linnaeus), turnstone, 8 inches long; in winter: dusky brown, feathers edged with ashy-brown; abdomen white; upper parts marked with black and rufous or chestnut. In summer: sides of neck and breast black. Migratory species, usually seen in small flocks, which rise together. On wing recognized by distinct flicker of black, white and (in summer) chestnut. Frequents sea beaches and mud flats, turning stones in search of worms and marine creatures; roosts at night on rocky points near shore. One turnstone was seen by Fosberg in October, 1953.

Crocethia alba (Pallas) [formerly called Tringa arenaria], sanderling; 7-8 inches long; in winter: pale gray above; head, back, rump with black central area on each feather; under parts white; bill and feet black. In spring, becomes spotted and streaked with black. Catches marine organisms following retreating waves, on beaches. Migratory species.

Erolia acuminata (Horsfield), sharp-tailed sandpiper; 8 inches long [probably rare]. Winter adult: grayish-brown above, streaked and striped dusky; white stripe over eye; chest sides and breast pale grayish-buff; abdomen white. In summer: upper parts brighter, with rusty and black; lower parts streaked dusky and grayish-brown V-shaped marks. Migratory species Siberia to New Zealand.

[Other possible migratory species which might visit Wake]

Green-winged teal,	<u>Anas crecca carolinensis</u> Gmelin
Pintail [duck],	<u>Anas acuta tzitzihua</u> Vieillot
Widgeon [duck],	<u>Anas penelope</u> Linnaeus
Canvasback [duck],	<u>Aythya valisineria</u> (Wilson)
Black-bellied plover,	<u>Squaterola squaterola</u> (Linnaeus)
Semipalmated plover,	<u>Charadrius hiaticula semipalmatus</u> Bonaparte
Mongolian dotterel,	<u>Charadrius mongolicus stegmannii</u> Stresemann
Whimberel,	<u>Numenius phaeopus variegatus</u> (Scopoli)
Greater yellow-legs,	<u>Tringa melanoleuca</u> (Gmelin)

Family STERNIDAE, terns [by some included with gulls in the Laridae]

Sterna fuscata oahuensis Bloxam, sooty tern; very abundant, according to Bailey. Sooty-black above; forehead, sides of head, outer tailfeathers and underparts white; bill and feet black; 15-17 inches long. Lays one creamy-white egg, with variable spotting, in nest among bunchgrass. Catches small squid and fishes. In April 1952 a considerable rookery of sooty terns was observed by Fosberg on the lagoon side of Peale Islet. There were many young, varying from the pin-feather stage, light gray downy beneath and sooty brown on back and sides, to fully feathered, sooty brown speckled with white on the back, sooty gray beneath. This was not an especially large colony compared with those seen in the northern Marshall Islands. On July 18, 1952, C. J. Johnson reported that these birds had eggs. In 1953 this colony had moved to near the west end of Peale Islet after having been deliberately driven away from their old nesting place near the LORAN station. Their nesting was said to have been finished in July. In October a small number of adult birds were seen around the west end of Peale Islet. On the nesting site here were a small group of almost fully grown but more or less crippled young birds, also some dead ones. There was no obvious reason for the condition of these young birds.

Sterna lunata Peale, gray-backed or spectacled tern; 16-17 inches long; forehead, broad stripe over eye and underparts white; stripe through eye, top of head and nape black; upper parts dark ashy, paler on back of neck; bill and feet black.

Anous stolidus pileatus (Scopoli), noddy tern; 13-17 inches; sooty brown, grayer on neck, light gray on forehead. Young birds similar, but lack white on crown. Eggs less speckled than those of other terns, one laid in nest on ground. In April 1952 a few common noddies were seen by Fosberg, with one nest, but this may not have been occupied. In October, 1953, many more were seen on Peale Islet, roosting or flying with the frigate birds. One nest had a half-grown young.

Anous tenuirostris marculsi (Bryan), white-capped noddy; 13 inches; resembles noddy, but smaller; back, neck and under parts sooty black; forehead and crown white, becoming grayer on nape to merge with blackish on shoulder; narrow black mark over eye, white streak below eye. Prefers to nest on bushes; lays one egg.

Gygis alba candida (Gmelin), white tern, fairy tern or "love bird"; pure white except for black ring around eye and black feet. Balances single egg on limb of tree or bush fork. A few fairy terns were seen by Fosberg in both 1952 and 1953, mostly flying around the Pisonia forest.

[Other terns which might visit Wake Island]

Sterna sumatrana Raffles, black-naped tern; small, forked tail; plumage white, parts with pinkish cast; back, rump, tail, wing-coverts pale pearl-gray.

Sterna anaetheta Scopoli, bridled tern; like sooty tern but smaller, 14-15 inches, narrow white band on forehead extending back behind eyes; grayish brown below.

Thalasseus bergii pelecانoides (King), crested tern; large, white, with back, rump, tail, etc. pearl-gray; crown black with crest.

[For data on Micronesian birds, see Baker, Avifauna of Micronesia, U. of Kansas, 1951. Descriptions of sea birds: W. B. Alexander, Birds of the Ocean.]

REPTILES

The Tanager Expedition, in 1923, collected specimens of two species of geckos and two species of skinks on Wake Island. These can be distinguished as follows:

A. Geckos have their body covered with small granules or minute scales; the top of the head is without symmetrical shields; the digits (toes) are dilated, and the pupil of the eye is vertical. GEKKONIDAE

1. The chin (below the mouth) has small scales, not forming shields; inner digits have a compressed distal phalanx which extends somewhat beyond its tip, like a claw; color pale with dark spots or markings.

Lepidodactylus lugubris.

1'. Chin-shields large for at least two rows; inner digits without a distal, compressed phalanx; a series of transverse plates under the tail.

Peropus mutilatus.

B. Top of head with large symmetrical shields; body scales large, cycloid (thin, partially overlapping, with round outer edge, showing concentric growth lines); digits not dilated; pupil rounded. Skinks, SCINCIDAE

2. Eyelids well developed, movable; distinct light line down exact middle of upper surface from tip of snout to tail; bright blue-green tail. Emoia cyanura.

2'. Eyelids indistinguishable, not movable; without a light-colored, mid-dorsal line. Cryptoblepharus or Ablepharus boutonii poecilopleurus.

GECKOS

Lepidodactylus lugubris (Dumeril & Bibron), the "sad" or mourning gecko, has a variable coloration, ranging from pale gray, brown, tan or pinkish on the back, with dark spots or blotches, and white or pinkish lower surface, to very dark specimens, with or without a dark streak through the eye and along the side of the head. It is found from Indonesia to southeastern Polynesia, including Fiji, Samoa and many of the low sandy islets of the central Pacific. It is the commonest gecko in Hawaii, and is widespread in Micronesia. It lays pear-shaped eggs with white, hard, thick shells, about 9 by 6.5 mm., capable of falling and bouncing without breaking. These are found cemented together or to a vertical surface, with clusters in cracks, under loose bark or stones, and against boards.

Peropus mutilatus (Wiegmann), the stump-toed gecko, gets its specific name from the fact that its skin is so thin and tender that one can scarcely catch a specimen without its being "mutilated" in some way. Struggles of the gecko against one's fingers are likely to tear rents in the skin, and the tail is easily broken off. The color of this species also is variable, changing from light to dark to agree with the habitat in which it is found. The under parts are more or less tinted with yellow, which is more intense on the hind legs and belly. This species is widely distributed on Pacific islands from Mexico to the Philippines, especially on such low, reef islets as the Tuamotus and central Pacific atolls, also on higher islands such as the Society, Austral, Marquesas, Hawaii and Marianas.

SKINKS

Cryptoblepharus boutonii poecilopleurus (Wiegmann) formerly in Ablepharus, the snake-eyed skink, may be recognized most easily by the absence of eyelids and the absence of a light line down the exact middle of the back. Color is worthless in describing this species, for it may range from entirely dark to olive, brown, slaty, or even blue-green, uniform or having two to four lighter stripes on the back, but never an odd number (that is, with one in the exact center.) It is distributed throughout Polynesia (including Hawaii), and most of Micronesia. It loses its tail easily, but may regenerate a new one.

Emoia cyanura (Lesson), the azure-tailed skink, is recognized easily by its sharply defined, light mid-dorsal line, which extends from the tip of the snout to the tail, which is bright blue. Most adults have the central light strip on an even, dark brown to black ground; some have three yellow or white stripes; in older specimens these may fade and almost disappear. Some authorities place this species in the genus Lygosoma. It occurs in many islands in the Pacific, and is found throughout Micronesia. The egg measures 7 by 11 to 14 mm.; the skinks, 120 to 138 mm. in overall length. In 1952 this skink was fairly common about the island and Fosberg collected one on the ground in an open place.

In March 1949, C. Morgan Holmes collected what is believed to have been a "cat snake" in a tree on Wake. This snake has been identified as Boiga irregularis (Merrem), family Colubridae, subfamily Boiginae. It may be recognized by its large ventral plates, which stretch across the lower surface, several times longer than dorsal scales. It has 17 to 23 rows of scales, counted around the middle. The color is highly variable: yellowish, gray, olivaceous, bluish, greenish and brown above, uniform or spotted. It has been found in New Guinea, the Bismarck Archipelago, and the Solomon Islands, and probably reached Wake from one of these.

FRESHWATER FISH

Gambusia affinis

Mosquito fish.

In 1952 mosquito fish were seen by F. R. Fosberg in ponds and bomb craters, as well as in a large cistern. These had been spread about 8 months earlier to the ponds and bomb craters by Mr. Fred Schultz, as a part of his campaign against mosquitoes, from a stock introduced into the concrete cistern on Peale Islet 4 years before from Hawaii. They were very numerous in October, 1952, although it was not clear what they lived on, since the mosquito population had been reduced almost to the vanishing point.

INSECTS AND OTHER LAND ARTHROPODS

The insects collected by the "Tanager Expedition" were reported in Bulletin 31 of Bishop Museum, by the writer and collaborators, 1926. Other notes on insects are given by Aldrich, 1931, Bryan, 1948, Cresson, 1934, Hull, 1937, Jacot, 1928, 1929, Jordan 1939, Reeves, 1953, Rosen, Reeves and Aarons, 1948, Thompson, 1938, Usinger, 1937, 1941, 1946, 1949, and 1951, Van Zwaluwenburg, 1948, Wheeler, 1934, and Williams, 1945 (see Bibliography for complete citations).

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Vegetation and flora of Wake Island

by

F. R. Fosberg

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Introduction

Wake Island is a coral atoll lying north of the Marshall Islands at Latitude 19°17' North, Longitude 16°17' West. Although separated from Pokak, northernmost of the Marshalls by almost 550 kilometers, it is so similar to the Marshall Islands in most respects that it could almost as well be regarded as one of that group as an isolated island.

It is a low flat atoll, its land area composed of three islets, Wake, Wilkes, and Peale, forming a V open to the northwest, surrounding a lagoon, the northwest end closed by a reef. A map of the atoll, as it was prior to the war, is given by Bryan (1942, p. 208). The southeast extremity is Peacock Point, named for one of the ships of the U. S. Exploring Expedition.

Climate

The climate is described by the U. S. Weather Bureau (1957) as follows:

"The climate of Wake is maritime and is chiefly controlled by the easterly trade winds which dominate the island throughout the year. Occasionally during late fall, winter, and early spring, polar outbreaks reach the island and are marked by temperature drops of several degrees, increased cloudiness, and light to moderate showers of short duration. The winds during these outbreaks swing into the northerly directions and may reach gust velocities of forty miles per hour. After a few days the weather is modified and normality reigns again. It was during one of these outbreaks that the record low temperature of 64° F, was recorded.

"Frequent tropical disturbances (low pressure systems, aloft and/or surface) approach the island from the southeast quadrant during the late summer and early fall months. These systems bring about periods of light wind, high temperatures and humidities, and moderate to heavy rain showers. When the system is vigorous and close to the island, winds strengthen and showers may be prolonged to several hours duration. Although typhoons are not usual, two have occurred at Wake since observations were begun in 1935: October 19, 1941, and September 16, 1952. Winds were up to 140 and 180 miles per hour respectively during the storms.

"Clouds at Wake are predominately cumulus types with little difference in amounts from day to night. High cloudiness, rare during the winter months, occurs in association with fall and summer tropical disturbances.

^{1/}Botanist, U. S. Geological Survey, Washington, D. C.

"Seemingly, showers, which account for most of Wake's precipitation, occur most frequently between midnight and sunrise; however, sufficient records have not been accumulated to be certain of the diurnal nature. The sky is seldom completely overcast, nor, on the other hand, is the sky often completely clear.

"Thunderstorms are infrequent, but do occur along with the tropical disturbances, however, hail has yet to be reported at the surface. Fog, also, is unknown to Wake."

The mean annual precipitation, based on records from 1935 to 1941, 1947-1956, is given as 39.03 inches.

Soils

The soils are generally coral gravel or rubble of varied textures or in places largely coral sand, with here and there a slight coloring by humus. Under the Pisonia-Cordia forest a thin black friable humus layer lies on the coral. In one spot, the site of an old Japanese garden, is a small area of dark brownish gray fine soil. Part of this is a cemented platform of brown rock which a spectrographic analysis by Helen Worthing and Catherine Valentine, U. S. Geological Survey, showed to be phosphatic, with more than 10% phosphorus. No other consolidated rock was noticed except along the north coast of Wake Islet, where there is a long stretch of beach-rock below high tide level, overlain landward by beach conglomerate.

Vegetation

The vegetation of Wake is low and the general appearance is gray. Most of the atoll is covered by an open scrub forest, mainly of Tournefortia, except where this has been cleared to make room for the air-field and other installations. Its aspect is similar to that of Pokak Atoll in the Marshalls, but the vegetation is somewhat more luxuriant and is definitely richer in native species, as well as in the many introduced ones.

The first scientific information on the vegetation of Wake was published by Pickering (1876), an account of observations made there in 1841 by the naturalists of the U. S. Exploring Expedition, including Pickering, himself. This account notes: "marks of a hurricane that had passed over the island from the Northeastward", absence of house-flies, absence of coconut palms, Pandanus, and Urticaceae, presence of rats and lizards, and that there were no certain indications of the visits of humans. No formal description of the vegetation is given but thirteen species of plants are listed, with brief notes on the occurrence of some of them. About the only difference from later accounts is that Pemphis is said to be the prevailing plant. Tournefortia is described as abundant. The plants are mentioned below under what seem to be their modern names. A few had been listed by Gray (1854). The similarity of the lists of species recorded by Pickering and that given by Christophersen (1931) based on collections

made 80 years later is striking. One species had apparently disappeared, and two additional native species were found by the later collectors. Four species had been introduced in the interval, presumably by the few casual visitors and the Japanese birdhunters.

The vegetation of Wake was very well summarized by Christophersen (1931) who wrote up the botanical results of the Tanager Expedition of 1923, though he was not a member of that party. He quoted briefly from Wilkes, who visited the atoll in 1841, and more extensively from the field notes of E. H. Bryan who was a member of the Expedition. Judging from Bryan's observations, the vegetation was in fairly natural condition at the time of his visit, though the presence of Portulaca oleracea, Nicotiana, Gossypium and, perhaps, of Ipomoea pes-caprae, suggests the influence of man. Lepidium o-waihiense, Sesuvium portulacastrum, and Heliotropium anomalum are three species found on Wake but lacking, so far as known, in the Marshall Islands flora. The last two of them are, however, known in the Marianas, and all three are found in Hawaii.

Christophersen reports 16 species of vascular plants, 12 of them probably indigenous. In the 33 years since the collections listed by him were gathered, 26 species have established themselves, at least temporarily, in a wild condition and about 47 species of cultivated plants are now growing either in pots or with some form of protection. Additionally, at least five other native plants, Fimbristylis cymosa, Portulaca samoensis, a second species of Boerhavia, Abutilon albescentis, and Lepturus gasparricensis, have been found. The last may well have been Bryan's "broad-leaved bunch grass" which he apparently did not find in fertile condition. Bryan's plant could also have been Digitaria gaudichaudii which is similar when it lacks flowers and fruits.

The vegetation is low, scrubby, and generally sparse, as would be expected on a rather dry atoll with a rainfall of about 1000 mm. a year. It is, however, subject to two sorts of climatic vicissitudes, both of which have occurred within the present decade, namely extreme droughts and typhoons. In addition, between 1941 and 1945, Wake was almost totally devastated by military activity.

The present paper reports observations and collections made during four visits, all short, made in October 1951, April 1952, July 1952, and October 1953. My appreciation is due to Mrs. Rubie Cox, Mr. Fred Schultz, Mr. T. Dudley Musson, Mr. B. H. Hall, and Mr. Edward H. Brown, for information, transportation, and other assistance during these visits.

Judging from Bryan's description the original vegetation of the atoll was mainly a low woodland of Tournefortia (Messerschmidia), mixed here and there with Pemphis or Cordia, and with smaller areas of pure Pemphis forest and Cordia scrub, and with, on the north arm of Wake Islet, a dense forest of Pisonia, Cordia, and Tournefortia. Along the lagoon were areas of matted succulent Sesuvium and of a shrubby growth of Pemphis. Between the trees of the Tournefortia woodland was a sparse herbaceous and small shrubby growth of Lepturus, Heliotropium, Boerhavia, Lepidium, and Sida. Single small patches of Gossypium and

Ipomoea pes-caprae occurred, the latter on the site of an abandoned Japanese camp dating from 1908. Ipomoea tuba was generally distributed, twining over rocks, bushes, and trees. Because of the abundance of dead limbs and trunks noted by Bryan, it is suspected that a typhoon may have swept the island not long previously.

During the latter part of 1941 the atoll was extensively fortified by a small American force, after which it suffered an extended attack ending in its capture by the Japanese on December 23, 1941. After this the fortifications were greatly extended by the Japanese, leaving scarcely any of the ground untouched. Ditches, tank traps, platforms, ruined buildings, gun emplacements, revetments, and underground installations were almost everywhere, with refuse of all sorts very abundant. According to T. D. Musson, in 1947 the vegetation generally over the island was about a foot high, with the exception of a few small areas. During the three years of Japanese occupation the island was subjected to almost daily bombardment by American planes and occasionally by ships. Anything edible in the vegetation was consumed by the starving Japanese, who also planted gardens in some places.

By 1949, as shown by the excellent photos by Bailey and Niedrach (1951, pp. 47-62), the Tournefortia trees were already at least 3 m. tall.

In 1952, the dominant vegetation over most of the atoll was a stand of Tournefortia 3-5 m. tall. Its recent origin was obvious from the lack of trunks more than 10 cm. thick and from the fact that it grew on embankments and piles of coral rubble that clearly dated from the war. Two areas, one near the east side of the lagoon, the other just east of the Trans-Ocean Airways compound, on the southwest limb of Wake Islet appeared to represent pre-war Tournefortia forest, with larger trees than usual. The latter of these areas had, in addition to the Tournefortia, fair sized Pemphis trees on the lagoon side that may have been part of the Pemphis forest seen by Bryan in 1923. A third area also seemed to have suffered rather less than most others. This was a portion of the dense forest described by Bryan on the north limb of Wake Islet. A forest of Pisonia, with trees up to almost a meter in diameter, with some admixture of large tangled Cordia trees was still very prominent in 1952. The part of this area closest to the north beach, described by Bryan as having an impenetrable barrier of vegetation had, in 1952, only scattered herbs and bushes. Near Peacock Point were areas of a scrub growth of Cordia 1-2 m. tall, but probably grown up since the war. Scaevola sericea was mixed with the general Tournefortia woodland in some quantity only south of the air strip on the south leg of Wake Islet. Around most of the lagoon shore of Wake Islet was a broad belt of low Pemphis scrub, in places varied by Sesuvium flats. Though usually narrower, this belt in places reached 300 meters in width.

In the openings among the Tournefortia trees, in addition to the scattered native herbs and small shrubs, there was a thin dry vegetation of Euphorbia cyathophora and Cenchrus echinatus, obviously hard hit by the drought that had persisted from December to April. This had also affected noticeably most of the other plants. The Tournefortia had lost a good portion of its leaves, and, where growing on high embankments, in places looked quite dead. Pisonia and Cordia were more or less defoliated and Cordia in places dead at the tips of the branches.

Although in 1923 Bryan had noted only a single patch each of Gossypium and Ipomoea pes-caprae, in 1952 they were common in many places, especially around ruins of Japanese installations. Small grassy patches could also be seen here and there, some of them Cnodon dactylon which had been planted widely the previous fall but had not become very generally established. Other patches were Paspalum vaginatum, which was apparently a recent introduction but well established.

A short visit in July 1952, after the drought had broken, showed a more luxuriant picture. The bare spaces between the trees were green with grasses and a luxuriant growth of Euphorbia cyathophora. The trees on high ground that looked dead in April were still dead in July, but the others, mostly in lower places, looked far more luxuriant than on the previous visit.

During the first three visits relatively little planting of ornamentals or garden plants was observed. A few plants, including coconut, Crinum, Dieffenbachia, Polyscias guilfoylei, and Casuarina were growing behind shelters and windbreaks around the dispensary, and a few others in pots and boxes of imported soil. At the TAL (Transocean Air Lines) Compound were more extensive attempts at gardening. Around the buildings were one coconut tree and one Pandanus tree, both at least 2 m. tall, and small plants of Casuarina, Ficus carica, Ficus rubiginosa, Euphorbia pulcherrima, Thespesia, Terminalia, Cucurbita pepo, and Catharanthus, as well as broomcorn. A number of other ornamentals and maize were growing in pots. The method of vegetable gardening used most successfully was in top soil piled about 15 cm. deep, surrounded by boards, watered well, and shaded with leafy branches of Tournefortia. In such frames were growing successfully tomatoes, lettuce, broccoli, parsley, dill, onions, beans, radishes, and cucumbers.

In September of 1952 a violent typhoon lashed the atoll. Winds reported as up to 140, or even 160, miles per hour, with gusts to 160 or 180, were experienced. A great deal of wind-driven flying gravel was observed by eyewitnesses, though it stopped as soon as water covered an area. Little topographic change resulted, as few waves actually swept the island. Some areas were covered, though, by water backed up from the lagoon. It was said by those who experienced the typhoon that all leaves, as well as some bark, were stripped from the trees apparently by flying gravel. The leaves, however, began to reappear after about 10 days. Very few trees were uprooted, though many were badly broken. The most conspicuous damage was that done by flying gravel.

A two day visit was made by me in October, 1953, especially to observe what recovery from the effects of the typhoon had taken place. The following account is quoted, almost verbatim, from notes made at that time:

"The present condition of the vegetation, after an unusually wet season, is one of notable luxuriance compared with April 1952 but the trees present a much more ragged appearance, with many dead branches and some tendency to lean and to be partially broken in one direction or another, depending on the locality on the island. In only a very few areas have many trees been actually uprooted, but enormous quantities of branches have been broken off and tend to make progress

through the undergrowth slow and difficult. Tangled masses of wreckage, twisted iron, bent corrugated sheets, and other debris are also strewn through the brush.

"The dead branches of trees are usually ones from which significant areas of bark have been stripped or ones that have been broken. Tournefortia and Pisonia trees suffered most, some of the latter being blown down. Cordia apparently resisted the wind more effectively, as relatively little dead wood is in evidence on it. The Cordia-Pisonia forest seems still to be quite intact, though some trees were blown down, especially Pisonia, which usually takes root where it touches the ground. The whole is quite tangled, choked with branches and fallen trees.

"The Tournefortia forest is also in most places still in reasonably good condition, but in a few places, such as east of the TAL Compound on Wake Islet and areas on the middle and east thirds of Peale Islet, it presents a very battered appearance, indeed, most of the trees being broken. The Tournefortia trees on high embankments near the TAL Compound that were dead in 1952 are now practically gone.

"There are now almost no areas of large Pemphis left, but it is difficult to tell if they were destroyed by the typhoon or by clearing to make roads and to put in other installations. The low brushy Pemphis at the east end of the lagoon was apparently killed back somewhat almost everywhere, but has largely recovered. Dead branches and top portions of plants are still very much in evidence.

"Two of the three patches of original forest that were still quite distinguishable in 1952 could not even be located this time. They apparently suffered more than the lower second growth. That near the east end of the lagoon, however, may have been destroyed by clearing. The Cordia scrub near Peacock Point is much greener and more luxuriant than before.

"The general effect of the typhoon in many places seems to have been to destroy or greatly inhibit the growth of young woody plants which were invading bare areas, so that many pioneer habitats have been maintained. This has encouraged a great spread and outstanding luxuriance of first-stage pioneers like Cenchrus echinatus, Cenchrus brownii, Boerhavia diffusa, Setaria verticillata, Euphorbia cyathophora, Eleusine indica, and Fimbristylis cymosa, and to a somewhat lesser extent, Portulaca oleracea (which seems to be hybridizing with P. lutea), Digitaria insularis, Euphorbia glomerifera, and others.

"Small but vigorous patches of Cynodon dactylon, Paspalum vaginatum, Cyperus rotundus, and Euphorbia prostrata are found here and there. Gossypium religiosum is local but widespread, and very uniform in appearance. Ipomoea pes-caprae, Portulaca lutea, Heliotropium anomalum, and Sida fallax are about as common as before. Heliotropium is colonizing actively the bare gravel flats and beaches on the west ends of Peale and Wilkes islets. Lepturus repens seems more widespread and common than before, but probably this may be due to the much wetter season. Lepturus gasparricensis, not seen before, forms a colony of perhaps 40-50 clumps near the west end of Peale Islet.

"A few scattered Scaevola bushes were seen in the brush south of the runway, and one at Peacock Point, but this species seems rarer than in 1952 and is completely gone from around the Terminal.

"Recently cleared areas come up to a thick Tournefortia scrub rather promptly. The antenna-area of the LORAN Station must be cleared every month or so. The Tournefortia sprouts grow up to about 0.8 m. in that time. The ground is dragged with a steel I-beam to break off the shoots. If this is not done the growth slows down so that they are about 1 to 2.5 m. tall after 3 or 4 months.

"The cultivated plants around the TAL Compound are growing well--Ficus carica is up to 1.5 m. tall and bearing fruit, Terminalia catappa is 1.5 m. tall and healthy. Carica papaya, Catharanthus roseus, Casuarina equisetifolia, and Hibiscus hybrids are in good condition. Two forms of Cassia are also in healthy condition and fruiting abundantly. Bauhinia sp. is chlorotic and badly eaten by insects. Cantaloupes are growing well and flowering and fruiting around the Communications Center, but are slightly chlorotic on exposed sides of the building. These formerly had to be pollinated by hand, but are now being visited by bees from a swarm recently brought from Honolulu. A resident reported that a single tomato plant had grown and fruited near the garbage dump. Casuarina has been planted and is growing at several places, and coconuts are being planted around all building areas. Crinum is still surviving and growing at the Dispensary.

"CAA personnel are much interested in planting around the buildings and are establishing an "arboretum and nursery" where they intend to start and grow plants. They have many cuttings and seedlings, obtained from Honolulu and Midway. Many potted plants such as Hymenocallis littoralis, Coleus scutellarioides and Casuarina are waiting to be planted out. Many of these will probably do well enough during this wet spell, but some may fail in a drought. They are being watered with brackish water from wells which is now rather fresh but which will be increasingly saline when the weather is drier. This is especially so since the wells are closely spaced, 6 or 8 of them in a row 15 m. or so apart, thus drawing excessively from one small part of the fresh-water lens."

These observations are of a rather random nature and it is a pity that they are not more up to date. The records of the presence and condition of certain exotic plants at a definite time may be of interest in later interpretation of the vegetation. From observations to date it appears that the Tournefortia woodland is a fairly stable stage in the development of vegetation in dry coral islands such as this. Undisturbed it may gradually give place to Pisonia or Pisonia-Cordia forest. With extreme fluctuations in rainfall, and especially with occasional typhoons this process is greatly retarded. Since the Tournefortia colonizes successfully bare sand and gravel, Tournefortia woodland may immediately succeed itself if destroyed by storms or other causes. Where the salinity is too high, Pemphis and Sesuvium form the normal vegetation.

The Vascular Flora

Plants have been collected on Wake Island by the U.S. Exploring Expedition in 1841, Pollock and his associates on the Tanager Expedition in 1923, R. J. Branckamp in 1936, Mr. Torrey Lyons in 1940, F. R. Fosberg in 1951, 1952 and 1953, and by Dr. and Mrs. John Z. Gaston, in 1952 and 1953. Possibly other collections have been made of which we have no record. Vascular plants have been recorded from Wake Island by Gray (1854), Pickering (1876), Bryan (1926), Christophersen (1931), Drummond-Hay (1939), Bryan (1942), and Fosberg (1955 a, b). In the present paper I have tried to collect together the records from all of these accounts, and to cite specimens from my own collections and those of others if I have examined them. A few species have been added from what seem to be reliable sight records even though no specimens were collected. Older records, made under names other than those used in the present list, are referred to their presumed modern equivalents, but with the older name given in parentheses. The fact that a species was recorded in my 1955 list is not mentioned here unless there has been a name change. Unfortunately I have not been able to examine any of the Gaston collections, and only a few of the Pollock, Branckamp, and Lyons ones, all of which are housed in the Bishop Museum. The collections cited below are deposited in the U. S. National Herbarium except those of Pollock, Branckamp, and Lyons. Species believed to have been introduced by man, rather than naturally, are indicated by an asterisk.

PANDANACEAE

*PANDANUS TECTORIUS Park.

Pandan, or Screw Pine.

A single tree 2 m. tall seen in 1952, planted in housing area. Characterized by stilt roots, thick, irregular branches, and linear leaves several feet long, with spiny margins and midrib.

GRAMINEAE

*CENCHRUS BROWNII R. & S.

Sand Bur, or Bur Grass.

A pioneer grass with bur-like fruits, similar to and often confused with the next, but the fruits are more numerous in narrower, longer, more compact spikes. Fosberg 34929.

*CENCHRUS ECHINATUS L.

Sand Bur, or Bur Grass.

A very common early pioneer weed, quickly covering open places; the fruit is a most annoying bur which scratches the skin and clings to clothing. Fosberg 33624.

*CHLORIS INFLATA Link

Finger Grass.

A common pioneer grass with several bristly purple spikes ascending from the top of the stem. Fosberg 34923.

*CYNODON DACTYLON (L.) Pers.

Bermuda Grass.

Certainly introduced and established since Bryan's visit in 1923, though possibly before the war; much more of it planted in 1951, according to local information. Forms dense mats of rhizomes, flowering stems slender, erect, with 3-4 radiating slender spikes. Fosberg 34931. (Bryan 1942, p. 213.)

*DACTYLOCTENIUM AEGYPTIUM (L.) Reich. Crowfoot Grass.

A tufted depressed grass with 4-5 stiff, pointed, thick flower-spikes radiating from the tips of the stems. Common in open situations. Fosberg 33617.

*DIGITARIA CILIARIS (Retz.) Koel. Tropical Crab Grass.

A slender spreading grass with very slender divergent spikes of flowers. Not abundant but found on Peale Islet repeatedly since 1940. Branckamp s.n. in 1936; Lyons 10; Fosberg 34936.

DIGITARIA GAUDICHAUDII (Kunth) Henr.

A rare strand grass, otherwise known only from the Marianas and possibly introduced from there, with broad leaves and close clusters of stiff spikes. This may be the "broad-leaved bunch-grass" mentioned by Bryan (Christophersen 1931, pp. 7-8), though it also may have been Lepturus gasparricensis, as vegetatively they look much alike. Lyons 13. (Bryan 1942, p. 213.)

*DIGITARIA INSULARIS (L.) Henr. Sour Grass.

An aggressive pioneer grass, forming erect bunches, the inflorescence a cluster of somewhat nodding, silky spike-like racemes. This has been known for a long time in Hawaii and has, since the war, appeared in a number of Micronesian islands, probably transported with war materials. Fosberg 34476. (Fosberg 1955a, as Tricachne insularis (L.) Nees)

*ELEUSINE INDICA (L.) Gaertn. Goose Grass.

A very common grass around dwellings and installations, forming rather coarse spreading tufts, inflorescence a cluster of flattened spikes spreading from the end of the stem. Fosberg 33623.

*ERAGROSTIS AMABILIS (L.) W. & A. Love Grass.

A spreading delicate grass with very fine open flower clusters, usually dark purplish; common in open places, especially gardens and around dwellings and installations. Fosberg 34459.

*ERAGROSTIS POAEOIDES Beauv. ex R. & S.

A rare tufted prostrate grass, similar to the preceding but with pale, longer spikelets of flowers; found once at the end of the airstrip, not found previously in the Pacific Islands. Fosberg 34458.

LEPTURUS GASPARRICENSIS Fosb.

A coarse bunchgrass with broad leaves and rather coarse jointed flower spikes, occurring in a restricted area toward the west end of Peale Islet, known only from here and from Pokak Atoll, in the Marshalls. Possibly the "broad-leaved bunchgrass" mentioned by Bryan (Christophersen 1931). Fosberg 34940. (Fosberg 1955a, as Lepturus sp.; Fosberg 1955b, p. 293).

LEPTURUS REPENS var. SEPTENTRIONALIS Fosb. Bunch Grass.

The common bunch grass, forming erect tufts with fine leaves and long slender spikes that become disjointed when ripe. U. S. Expl. Exped. s.n. in 1841; Branckamp s.n. in 1936; Lyons 10; Fosberg 33627, 34462, 34941, 34942, 34943, 34944, 34950. (Pickering 1876, p. 247, as Lepturus; Christophersen 1931; Bryan 1942, p. 213; Fosberg 1955a, all three as Lepturus repens (Forst.) R. Br.; Fosberg 1955b.)

*PASPALUM VAGINATUM Sw.

Salt Grass.

A wiry creeping, mat-forming grass, somewhat coarser than bermuda grass, forming patches locally. Fosberg 34932, 34949.

*SETARIA VERTICILLATA (L.) Beauv.

Bristly Foxtail.

A loose somewhat spreading grass with bristly pointed flower clusters that, when ripe, cling to clothing and thus cause the seeds to be scattered about; occurs very locally in semi-shaded areas. Fosberg 34470.

*SORGHUM DOCHNA var. TECHNICUM (Koern.) Snowd. Broomcorn.

Persisting, in 1952, very sparingly around old Japanese garden-sites, also seen at TAL Compound.

*ZEA MAYS L.

Maize, or Indian Corn.

Grown in drum of soil at TAL Compound in 1952; reached maturity but was very spindly and with only abortive ears.

UNIDENTIFIED GRASS

Pickering, 1876, p. 247, reported "Gramen incert., (No. 1; compare Tarawan coral-islands). Single stemmed, and large-leaved; resembling young Phragmites." There is nothing at present on Wake that would even remotely answer to this description.

CYPERACEAE

FIMBRISTYLIS CYMOSA R. Br.

A low tufted bright green grass-like plant, with open brownish clusters of flower-spikes on slender stems rising above the leaves; occurring very commonly from extreme pioneer situations to wooded places. It was surprising that this was not mentioned from Wake in the earlier descriptions, as it is most likely native and usually occurs abundantly wherever it is found. Fosberg 33619, 34457, 34478. (The Wake Island plant belongs to the form recently segregated from F. cymosa as F. atollensis St. John. It is, however, too close to what has been called F. spathacea Roth, and Kern, eminent student of sedges of the Malaysian area regards the whole complex as belonging to one species. Probably the plants of the Pacific atolls and seashores may constitute a good variety, distinguished from F. spathacea by smooth nuts and from F. cymosa by two stigmas and plane-convex nuts, but as yet this study is unpublished and it seems best to call the whole group simply F. cymosa.)

PALMAE

*COCOS NUCIFERA L.

Coconut Palm.

A few not too healthy seedlings which were planted in the shelter of the buildings were eliminated by the typhoon, but many have been re-planted.

ARACEAE

*CALADIUM sp.

Mentioned by E. H. Bryan (m.s.) as planted about houses.

*DIEFFENBACHIA sp. Dumb-Cane.

One potted plant seen in 1952.

*SCINDAPSUS AUREUS (Lind. & Andre) Engl. Pothos.

One or two potted plants seen in 1952.

PONTEDERIACEAE

*EICHHORNIA CRASSIPES (Mart. & Zucc.) Salms-Laub. Water Hyacinth.

One plant seen in a large cistern in 1952, said to be the only one remaining of a large number, the rest of which had been taken by the inhabitants to decorate aquaria.

BROMELIACEAE

*ANANAS COMOSUS (L.) Merr. Pineapple.

A rooted crown seen growing in a box of soil in 1952.

AGAVACEAE

*CORDYLINE TERMINALIS (L.) Kunth Ti.

Seen growing in pots in 1952.

*SANSEVIERIA ROXBURGHIANA Schultes Bowstring Hemp.

Seen growing in pots in 1952.

AMARYLLIDACEAE

*ALLIUM sp. Onion.

Seen growing in protected garden at TAL Compound in 1952.

*CRINUM sp. Crinum Lily.

Seen growing at dispensary in 1952 and 1953, but not flowering. May be distinguished from the spider lily by the spiral arrangement of the rosette of lance-shaped leaves and the lack of a web between the stamens.

*HYMENOCALLIS LITTORALIS (Jacq.) Salisb. Spider Lily.

Growing in pots in nursery in 1953, waiting to be planted out. The leaves of this are packed in a tight row, rather than spirally as in Crinum, and are linear and blunt at the apex.

CASUARINACEAE

*CASUARINA EQUISETIFOLIA L. Ironwood.

Planted, doing well around TAL Compound and buildings elsewhere in 1953; a tree superficially resembling a pine, but with "needles" jointed and bearing rings of tiny scales.

MORACEAE

*FICUS CARICA L.

Fig.

Planted around the TAL Compound, 1.5 m. tall and fruiting in 1953; recognizable by its roughish leaves with finger-like lobes. Fosberg 34466.

*FICUS RIBIGINOSA Desf.?

One small plant growing at the TAL Compound in 1952. Fosberg 34467.

POLYGONACEAE

*COCCOLOBA UVIFERA (L.) L.

Sea-Grape.

A coarse shrub with large round leathery leaves and edible grape-like fruits; rare but apparently naturalized in woody vegetation on Wake and Peale Islets, where it apparently survived the typhoon, as the clump on Peale Islet was 2.5 m. tall in 1953. Fosberg 34471, 34935.

NYCTAGINACEAE

BOERHAVIA DIFFUSA L.

A prostrate mat-forming plant with long reddish stems radiating from a thick fleshy root-crown, leaves obtuse, pale beneath, flowers pink; common generally. Fosberg 33626, 34453. (Pickering 1876?; Drummond-Hay 1939; Bryan 1942, p. 213.)

BOERHAVIA sp.

Similar to the above but with pointed leaves and white flowers, common in open places on sand. A distinctive species, known from Wake and the Northern Marshalls, perhaps also from Johnston I., usually referred to B. diffusa, but probably an undescribed species. Fosberg 34454, 34947. (Pickering 1876?; Christophersen 1931, as B. diffusa L.; Drummond-Hay 1939; Fosberg 1955a, as Boerhavia, form with leaves as in B. mutabilis R. Br.)

*BOUGAINVILLEA SPECTABILIS Willd.

Bougainvillea.

Mentioned by E. H. Bryan (m.s.) as a garden plant.

PISONIA GRANDIS R. Br.

Puka.

One of the principal species in the patch of low forest on the north-west leg of Wake Islet, a tree with thick white trunk, very soft wood; large green leaves, clusters of greenish flowers and club-shaped spiny glutinous fruits. Fosberg 34472. (Bryan 1926, p. 8; Christophersen 1931 as Ceodes sp.; Drummond-Hay 1939; Bryan 1942, p. 213.)

AMARANTHACEAE

*AMARANTHUS DUBIUS Mart.

Amaranth Pigweed.

Erect herb with slender nodding spikes of tiny green flowers; occasional along roadsides in scrub on Peale Islet. Fosberg 34938.

*AMARANTHUS GRAECIZANS L.

Amaranth Pigweed.

A depressed, small-leaved annual weed, collected on Peale Islet. Branckamp s.n. in 1936. (Bryan 1942, p. 213.)

*AMARANTHUS TRICOLOR L.

Amaranth Pigweed.

Erect plant, similar to A. dubius but spike not nodding; persisting around old Japanese garden site. Fosberg 34452.

*AMARANTHUS VIRIDIS L.

Chinese spinach.

Sprawling herb with small clusters of tiny green flowers; persisting around old Japanese garden site. Fosberg 34446.

AIZOACEAE

SESUVIUM PORTULACASTRUM L.

Seaside Purslane.

A prostrate very fleshy plant with glossy green leaves, reddish stems, and rose-link flowers; common generally in low saline places, forming a continuous mat just above lagoon level inside the passage at east end of Peale Islet. Fosberg 34461. (Gray 1854, p. 142; Pickering 1876, p. 247; Christophersen 1931, p. 11; Drummond-Hay 1939, Bryan 1942, p. 213, as pickle-weed.)

PORTULACACEAE

PORTULACA LUTEA Sol.

Giant Purslane.

Very fleshy herb with thick stems grayish near the base, ascending to erect, leaves broad at apex, flowers large, yellow, with many stamens; common generally in open places in scrub. Fosberg 34468. (Gray 1854, p. 139, as P. oleracea; Pickering 1876, p. 247, as Portulaca; Christophersen 1931, p. 11; Drummond-Hay 1939; Bryan 1942, p. 213.)

*PORTULACA OLERACEA L.

Purslane.

Similar to P. lutea but depressed, more slender, brownish green, stems not grayish at base, flowers small, with 12-17 stamens; occasional on bare ground around terminal and elsewhere, more abundant after the typhoon, apparently hybridizing with P. lutea. The Pacific plants have different seeds from the European plants and may be a distinct native species. This has been in Wake at least since 1923, when Pollock found it. Fosberg 33620. (Christophersen 1931, p. 12; Drummond-Hay 1939; Bryan 1942, p. 213.)

PORTULACA SAMOENSIS v. Poelln.

A prostrate plant with tuberous root, narrow pointed fleshy leaves with copious tufts of long hair at the base, and bright yellow flowers; rare in open places. This is a native Pacific Island species but possibly might be introduced on Wake, as it was not found earlier. Fosberg 34460.

CRUCIFERAE

*BRASSICA OLERACEA var. ITALICA Plenck. Broccoli.

Grown in sheltered raised beds of soil, watered well, at TAL Compound in 1952.

LEPIDIDIUM O-WAIIENSE C. & S.

Scurvy Grass.

A small rather stiff erect cress-like plant, noted by Bryan in 1923 as forming part of the undergrowth on the western parts of Wilkes and Peale Islets, and collected on all islets by Pollock, but in 1953 seen only in a flourishing colony on steep banks around "Lake Peale", a pond on Peale Islet. Fosberg 34930. (Pickering 1876, p. 247; Christophersen 1931, p. 13; Drummond-Hay 1939; Bryan 1942, p. 213.)

*RAPHANUS SATIVUS L.

Radish.

Grown in raised sheltered beds at TAL Compound in 1952.

CRASSULACEAE

*SEMPERVIVUM TECTORUM L.

Hen-and-Chickens.

Seen in pot in housing area in 1952.

*KALANCHOE PINNATA (Lam.) Pers.

Air Plant.

This, with two other unidentified species of Kalanchoe seen growing in pots in housing area in 1952.

LEGUMINOSAE

*BAUHINIA sp.

Orchid Tree.

Seen in pot at TAL Compound in 1952, still there in 1953 but chlorotic and badly eaten by insects; may be recognized by its leaves which are divided into two lobes at the apex.

*PHASEOLUS VULGARIS L.

Bean.

Grown in raised, sheltered garden bed at TAL Compound in 1952; mentioned by Drummond-Hay, 1939, as growing in hydroponic cultures.

EUPHORBIACEAE

*CODIAEUM VARIEGATUM (L.) Bl.

Croton.

Seen in pot at TAL Compound in 1952.

*EUPHORBIA CYATHOPHORA Murr.

Dwarf Poinsettia.

A herb up to 0.5 m. tall, with milky sap, top leaves, under the flower clusters, partly brilliant scarlet; very abundant in open places, mostly almost dead in dry period in April, 1952, but flourishing after rains in July. Fosberg 34474. (Commonly but incorrectly referred to as Euphorbia heterophylla L., which is a related species much less common in the Pacific.)

*EUPHORBIA GLOMERIFERA (Millsp.) Wheeler Spurge.

A delicate erect milky herb or slender shrub, arching at tips, with tiny white flowers; common around Terminal in 1951, had spread widely in open ground and was common after the typhoon in 1953. Fosberg 33618, 33622. (Commonly but apparently incorrectly called E. hypericifolia L.)

*EUPHORBIA HIRTA L.

Hairy Spurge.

A small arching milky hairy herb with pointed leaves and clusters of tiny white flowers; local on bare ground around Terminal. Fosberg 33628.

*EUPHORBIA PROSTRATA Ait.

Prostrate Spurge.

A tiny prostrate purplish plant with milky sap; rare in open gravel on Wake Islet in 1952, occasional in bare spots on Peale Islet in 1953. Fosberg 34455, 34939.

*EUPHORBIA PULCHERRIMA Willd.

Poinsettia.

Small plants seen at TAL Compound in 1952.

*PHYLLANTHUS AMARUS Schum. & Thonn.

Reported as a weed by E. H. Bryan (1942) (as P. niruri L.), probably P. amarus but specimen not seen.

MALVACEAE

ABUTILON ALBESCENS Miq.

Shrub 1 m. tall with velvety leaves, orange flowers and hairy pappery fruit segments; one plant seen in 1952 near old Japanese installation. Fosberg 34451. (Generally referred to A. indicum (L.) Sweet, from which it differs in aspect, much larger flowers, and different fruit, probably actually closer to A. asiaticum (L.) D. Don.)

*GOSSYPIUM RELIGIOSUM L.

Wild Cotton.

A spreading reclining shrub with grayish leaves, light yellow flowers, and diminutive cotton-producing fruits. Bryan reported one clump in 1923, but in 1952 fairly common especially around old Japanese installations on Wake Islet. Native in the Pacific, but rare and known from very few specimens, probably but not certainly an introduced plant on Wake, first found there in 1923. Fosberg 34469. (Christophersen 1931, p. 13, as G. hirsutum var. religiosa W-tt; Drummond-Hay 1939; Bryan 1942, p. 213, also as G. hirsutum var. religiosa.)

*HIBISCUS (ornamental hybrids)

Hibiscus.

Seen in 1953 at TAL Compound, growing very well.

SIDA FALLAX Walp.

Lima.

A gray-leaved shrub with dull orange flowers; scattered generally in sparse scrub and in openings, about as abundant after the typhoon as before. Fosberg 34945. (Gray 1854, p. 161; Pickering 1876, p. 247; Christophersen 1931, p. 13; Drummond-Hay 1939; Bryan 1942, p. 213.)

*THESPESIA POPULNEA (L.) Sol. ex Correa Milo, or Portia Tree.

Seen in 1952 planted at TAL Compound.

PASSIFLORACEAE

*PASSIFLORA sp.

Water Lemon.

"Some kind of water lemon seen in the 1940's" according to E. H. Bryan (m.s.).

CARICACEAE

*CARICA PAPAYA L.

Papaya.

Seen growing at TAL Compound, in 1952 said to reach only a few dm. in height and then to die, but in 1953 appeared in good condition.

CUCURBITACEAE

*CUCUMIS MELO L.

Cantaloupe.

Growing well and fruiting around Communications Center in 1953. Formerly had to be hand pollinated, but later a swarm of bees was brought from Honolulu and these visited the blossoms regularly, according to local information.

*CUCURBITA PEPO L.

Pumpkin.

Growing in raised sheltered garden plot at TAL Compound in 1952; a squash is also mentioned by Drummond-Hay (1939) as growing in hydroponic culture.

LYTHRACEAE

PEMPHIS ACIDULA Forst. f.

A closely branched shrub or small tree with very hard wood, small leaves with an astringent taste, and white flower, that is one of the dominant plants on certain areas of the island, forming scrubby forests locally east and south of the lagoon and scrub around the lagoon margin. (Gray 1854, p. 601; Pickering 1876, p. 247; Bryan 1926, p. 8; Christophersen 1931, p. 14; Drummond-Hay 1939; Bryan 1942, p. 213.)

COMBRETACEAE

*TERMINALIA CATAPPA L.

Indian Almond.

A tree with large obovate leaves which turn red before falling and somewhat flattened egg-shaped fruits with a keel along one side and a point; seen planted around the TAL Compound in 1952. It survived the typhoon and was growing well in 1953.

MYRTACEAE

*EUCALYPTUS CITRIODORA Hook.

Lemon-Scented Eucalyptus.

Seen growing in a pot at TAL Compound in 1952.

ARALIACEAE

*POLYSCIAS GUILFOYLEI (Cogn. & March.) Bailey Hedge Panax.

Seen growing in pot at Dispensary in 1952. Said to grow well, reaching a height of two feet in calm season, only to be cut down almost to ground by dry winds during windy weather.

UMBELLIFERAE

**ANETHUM GRAVEOLENS* L.

Dill.

Seen growing in raised, sheltered garden plot at TAL Compound in 1952.

**APIUM PETROSELINUM* L.

Parsley.

Seen growing in raised, sheltered garden plot at TAL Compound in 1952.

SAPOTACEAE

**CHRYSOPHYLLUM CAIMITO* L.?

Star Apple.

Seen growing in pot at TAL Compound in 1952.

APOCYNACEAE

**CATHARANTHUS ROSEUS* (L.) G. Don

Periwinkle.

A small erect herb 3-4 dm. tall, with opposite oblong leaves and terminal clusters of flowers, varying on different plants from white to magenta; first reported in 1940 by Torrey Lyons, seen growing in sheltered places around TAL Compound and Dispensary in 1952 and 1953, rare in open places elsewhere in 1952 but apparently not so widespread in 1953. Fosberg 34456.

CONVOLVULACEAE

**IPOMOEA BATATAS* (L.) Poir.

Sweet Potato.

Said to have grown luxuriantly at the Dispensary when sheltered from wind, but parts exposed to wind were killed instantly. Later insects ate the whole patch. Also seen in 1952 persisting, but rare, around old Japanese garden site on Wake Islet. Fosberg 34449.

**IPOMOEA PES-CAPRAE* ssp. *BRASILIENSIS* (L.) v. Ooststr. Beach Morning-glory.

A prostrate extensively spreading creeper with leaves with two rounded lobes at the tip and rose-purple flowers. Bryan reported one patch, near an old Japanese encampment near the east end of Peale Islet in 1923 (Christophersen 1931, p. 8); it is now common locally in many parts of Wake and Peale Islets. Although commonly regarded as native in most tropical strand habitats, it is probably introduced on Wake Atoll. Fosberg 34473. (Christophersen 1931, p. 14; Bryan 1942, p. 213, both as *Ipomoea pes-caprae* (L.) Roth.)

IPOMOEA TUBA (Schlecht.) Don

Moon Flower.

An extensive creeper and climber with heart-shaped leaves and large white flowers which open at night; very common generally. Fosberg 33614. (Pickering 1876, p. 247, as "*Ipomoea turpethum*?"; Christophersen 1931, p. 14, as *Calonyction grandiflorum* (Jacq.) Choisy; Drummond-Hay 1939, as morning-glory; Bryan 1942, p. 213, as *Ipomoea grandiflora.*)

BORAGINACEAE

CORDIA SUBCORDATA Lam.

Kou.

A shrub or small tree with ovate or elliptic rather large leaves and showy brilliant orange flowers; dominant or codominant in two vegetation types, the Pisonia-Cordia forest and the Cordia scrub, both on Wake Islet, occasional elsewhere. Fosberg 34480. (Pickering 1876, p. 247, as Cordia; Christophersen 1931, p. 14; Drummond Hay 1939, Bryan 1942.)

HELIOTROPIUM ANOMALUM H. & A.

Beach Heliotrope.

A low silvery leafed fleshy herb or dwarf shrub with dense clusters of yellowish-white very fragrant flowers; common generally in bare places and openings in scrub, one of the first pioneer plants to appear on beaches. Fosberg 33625. (Pickering 1876, p. 247, as "(Pentacarya? No. 2, or compare) Tournefortia"; Bryan 1926, p. 8; Christophersen 1931, p. 14; Drummond-Hay 1939; Bryan 1942, p. 213.)

TOURNEFORTIA ARGENTEA L. f.

Tree Heliotrope.

A low rounded tree or shrub with fleshy obovate silvery or frosty appearing leaves and clusters of small fragrant white flowers; dominant in the vegetation of the largest parts of all three islets. Commonly called "scaviola" on the island, which seems to be a corruption of Scaevola, the name of another plant of vaguely similar appearance. This usage should be discouraged as it is likely to be confusing. Fosberg 33625. (Pickering 1876, p. 247, as Tournefortia; Bryan 1926, p. 8; Christophersen 1931, p. 15; Fosberg 1955a, as Messerschmidia argentea (L. f) Johnst., which is the correct name if this plant is separated from the other species of Tournefortia of tropical America as a different genus and associated with a diminutive Siberian plant of alkaline or salty places. This question is not yet settled.)

LABIATAE

*COLEUS SCUTELLARIOIDES L.

Coleus.

Seen growing in pot in nursery in 1953, would probably not survive under Wake Island conditions without protection.

SOLANACEAE

*CAPSICUM ANNUUM L.?

Pepper.

A plant probably belonging to this species seen growing well, flowering and fruiting, in protected garden plot at TAL Compound in 1953.

*CAPSICUM FRUTESCENS L.

Chili-Pepper.

Growing well and fruiting at TAL Compound in 1952 and 1953, apparently survived the typhoon. This is the pepper with very small carrot-shaped very hot fruits.

*NICOTIANA TABACUM L.

Tobacco.

An erect somewhat greasy-feeling herb, up to 6-8 dm. tall, with pink flowers; rare, persisting in 1952 around old Japanese garden site, status in 1952 very much as reported by Christophersen thirty years earlier. Fosberg 34448. (Christophersen 1931, p. 15; Bryan 1942, p. 213.)

**SOLANUM LYCOPERSICUM* L.

Tomato.

Growing in raised sheltered garden plot at TAL Compound in 1952, in 1953 one plant said to have grown and fruited near the garbage dump; mentioned by Drummond-Hay (1939) as being grown in hydroponic culture.

GOODENIACEAE

SCAEVOLA SERICEA Vahl

Scaevola; beach magnolia.

A low rounded shrub with bright green leaves, white flowers that appear to have been torn in half, and white fleshy fruits; occasional in scrub vegetation on Wake Islet, especially along the air strip and near Peacock Point, much less common in 1953 than in 1952, and less common in 1952 than appears from Bryan's notes in 1923 (Christophersen 1931, pp. 6-7); not seen on either Wilkes or Peale Islets in 1952 or 1953, but reported from Wilkes by Christophersen. Fosberg 33616. (Pickering 1876, p. 247, as Scaevola; Bryan 1926, p. 8; Christophersen 1931, p. 15; Bryan 1942, p. 213; Fosberg 1955a, p. 21, the last four as Scaevola frutescens (Mill.) Krause. This name is based on a specimen from the West Indies which belongs to a different species.)

COMPOSITAE

**CONYZA BONARIENSIS* (L.) Cronq.

Horse Weed.

A tall coarse herb with many heads of tiny whitish flowers; rare along roadsides on Wake Islet. Fosberg 34463.

**LACTUCA SATIVA* L.

Lettuce.

Seen growing in raised sheltered garden plot at TAL Compound in 1952; reported by Drummond-Hay (1939) as grown in hydroponic culture.

**PLUCHEA ODORATA* (L.) Cass.

An aromatic grayish pubescent shrub with clusters of heads of small pale purplish flowers; common in waste places and openings, especially near the airstrip. Fosberg 33621.

**SONCHUS OLERACEUS* L.

Sow-Thistle.

An erect milky herb with pale yellow flowers; a rare weed around dwellings and along roadsides. Fosberg 34464, 34483.

The Cryptogamic Flora

Very few cryptogams are known to have been collected on Wake Island. Two brackish water green algae may be recorded, both tentatively identified by Wm. Randolph Taylor.

CLADOPHORACEAE

RHIZOCLONIUM HOOKERI Kg.?

Forming filamentous green masses in brackish pools in bomb craters, Wake Islet. Fosberg 34479.

ULVACEAE

ENTEROMORPHA FLEXUOSA (Walf.) J. Ag.?

Forming a dense turf on bottom of an intermittent pool, varying with tide, without water when collection was made, in bottom of an inland artificial depression. Fosberg 34475.

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ATOLL RESEARCH BULLETIN

No. 68

Additional records of phanerogams from the northern Marshall Islands

by

F. R. Fosberg

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Additional records of phanerogams from the northern Marshall Islands

by
F. R. Fosberg^{1/}

The principal easily available lists of plants growing in the Marshall Islands north of Lat. 7°30' N. are in Taylor, Plants of Bikini, 1950, and Fosberg, Atoll Research Bulletin No. 39, 1955. In addition to these a list is provided in Fosberg, Military Geography of the Northern Marshalls, 1956, and there are scattered records throughout the literature of systematic botany, mostly based on the collections of Chamisso, made in 1817, and referred to as from "Radack". Most of these were probably collected on Odtia (the modern Wotje) and originally identified by Chamisso and Schlechtendal.

The botanical names were brought up to date in the 1955 list, but further research has resulted in a few more changes. Additional collecting, principally on a trip made under the auspices of the U.S. Naval Radiological Defense Laboratory in February, 1956, to Rongelap, Rongerik, Ailinginae, Utirik, Likiep, and Kwajalein atolls has yielded a considerable number of new distributional records from these atolls. These are here placed on record, along with certain corrections in the nomenclature used in the 1955 list and in Taylor's book. Following the practice adopted in the 1955 list only the name of the atoll and of the islet and collector's number are given, the numbers being in the author's consecutive series. The specimens have been or will be deposited in the U. S. National Herbarium, with duplicates, when available, in the B. P. Bishop Museum. Records are not cited from additional islets in atolls where the species concerned are already known. Brief generalized notes are added on occurrence and other matters of interest. Introduced species are indicated by an asterisk.

Polypodium scolopendria Burm. f.

Ailinginae Atoll: Sifo I., 36675

Very local in scrub forest.

*Cycas circinalis L.

Likiep Atoll: Likiep I., 36632.

Planted tree 5 m. tall, said to have been brought from Arno Atoll.

Pandanus tectorius Park.

Ailinginae Atoll: Sifo I., 36673. Rongerik Atoll: Eniwetak I., 36705.

Rare in scrub and in Cordia forest.

*Chrysopogon aciculatus (Retz.) Trin.

Kwajalein Atoll: Kwajalein I., 39277.

Established in lawn at air terminal, somewhat protected and semi-shaded.

^{1/} Botanist, U. S. Geological Survey, Washington, D. C.

*Cynodon dactylon (L.) Pers.

Likiep Atoll: Likiep I., 36726.

In lawn around church.

*Digitaria ciliaris (Retz.) Koel.

Kwajalein Atoll: Kwajalein I., 39499.

Occasional in waste ground near airstrip; probably a recent introduction.

*Digitaria insularis (L.) Henr.

Listed in 1955 as Tricachne insularis (L.) Nees, but referred to as Digitaria by Henrard in his monograph of Digitaria.

Digitaria pruriens var. microbachne (Presl) Fosb.

Ailinginae Atoll: Sifo I., 36688.

Found only in one small opening in the forest.

Listed in 1955 as Digitaria microbachne (Presl) Henr. but better regarded as a variety of the widespread D. pruriens.

*Eragrostis amabilis (L.) W. & A.

Rongerik Atoll: Eniwetak I., 36699.

Common in cleared strip.

Lepturus gasparricensis Fosb.

This was reported from Pokak Atoll in the 1955 list as Lepturus sp. It has the distinction of being one of the few species of vascular plants endemic to coral atolls, being known only from Pokak and Wake Atolls.

Lepturus repens (Forst. f.) R. Br.

Since the 1955 list a discussion of the Pacific forms of Lepturus has been published (Fosberg, Occ. Pap. Bishop Mus. 21: 285-294, 1955) and a number of varieties were recognized in Lepturus repens. In the northern Marshall Islands the following were found to occur, of which most of the specimens were cited in the 1955 list under L. repens: Var. repens from Eniwetak Atoll, var. subulatus Fosb. from Eniwetak, Bikini, Utirik, Ujelang and Wotho atolls, var. septrionalis Fosb. from Pokak, Bikar, Eniwetak, Bikini, Rongerik, Taka, Ailuk, Jemo, Likiep, Kwajalein, Lae, and Ujelang atolls, and var. occidentalis Fosb. from Eniwetak Atoll.

To these may be added the following new records: var. subulatus, Kwajalein Atoll, Kwajalein I., 36642, and var. septrionalis, Ailinginae Atoll, Sifo I., 36678; Rongelap Atoll, Rongelap I., 36652, Eniaetok I., 36664, and Kubelle I., 36667.

*Paspalum fimbriatum HBK.

Kwajalein Atoll: Kwajalein I., 36644.

Established in waste ground near the airstrip, previously known in the Pacific from Hawaii and Guam.

*Paspalum setaceum Michx.

Kwajalein Atoll: Kwajalein I., 36641 (determined by Agnes Chase), 39488.

Well established in waste ground near the airstrip, not previously reported from the Pacific Islands, native of southeastern United States.

Thuarea involuta (Forst.) R. & S.

Ailinginae Atoll: Sifo I., 36696.

Forming ground cover in some areas in open forest.

*Cyperus polystachyos Rotth.

Kwajalein Atoll: Kwajalein I., 39490.

Local along airstrip.

*Cocos nucifera L.

Ailinginae Atoll: Sifo I., not collected. Rongerik Atoll:

Eniwetak I., not collected.

Several small groves on Sifo Islet in the interior.

*Rhoeo spathacea (Sw.) Stearn

Usually known as R. discolor (L'Her.) Hance and thus reported in 1955, but R. spathacea is an earlier name and the correct one for this widely planted tropical ornamental (see Stearn, *Baileya* 5: 195-198, 1957).

*Crinum asiaticum L.

Planted generally on Kwajalein Islet as an ornamental.

*Crinum bakeri Engl.

Utirik Atoll: Utirik I., 36713.

Planted along paths in village. This species has hitherto been known only from the original collection, made by Finsch on Mille Atoll, southern Marshalls in 1888. It was previously regarded as possibly based only on a badly prepared or abnormal specimen of C. asiaticum, in which the perianth tube is shorter than the lobes. However, the Utirik plants, seemingly perfectly normal, have this character, as well as crispate margined perianth segments.

*Crinum latifolium var. zeylanicum (L.) Hook. f. ex Trim.

Likiep Atoll: Likiep I., 36723.

Planted in gardens.

*Hippeastrum puniceum (Lam.) Urban

Likiep Atoll: Likiep I., 36727.

Planted in gardens.

Tacca leontopetaloides (L.) O. Ktze.

Ailinginae Atoll: Sifo I., 36692.

Common in forest and coconut groves.

*Casuarina equisetifolia L.

Likiep Atoll: Likiep I., 36630.

Tree 8 m. tall growing in garden on Likiep; planted also on Kwajalein and there apparently occasionally spontaneous from seeds of planted trees.

*Peperomia obtusifolia (L.) A. Dietr.

Likiep Atoll: Likiep I., 36724.

Growing in pot in shelter of buildings.

Peperomia ponapensis C. DC.

Recorded from Lae Atoll as Peperomia sp. in 1955, specimen since identified by T. G. Yuncker.

Fleurya ruderalis (Forst. f.) Gaud. ex Wedd.

Rongelap Atoll: Gegen I., 36737; Kabelle I. 36671; Ailinginae Atoll: Sifo I., 36691.

Locally common, especially on rocky ground, plants on Gegen in very poor condition.

*Artocarpus altilis (Park.) Posb.

Rongelap Atoll: Rongelap I., planted in village, fruit preserved for analysis, but no herbarium specimen made.

*Artocarpus mariannensis Trec.

The following records, now referred to A. mariannensis were in 1955 reported as A. altilis: Utirik Atoll, 33691. Ujae Atoll, 34417. Lae Atoll, 34091. Ailuk Atoll, 33924, 33957. Likiep Atoll, 33840, 36633. In addition, a specimen from Eniwetok Atoll, St. John 23714 and one from Rongelap Atoll, Taylor 46-1399, both in the U.S. National Herbarium seen to belong to A. mariannensis. From Wotho Atoll, Fosberg 34233 and from Bikini Atoll, Taylor 46-1146 seem to be hybrids between A. altilis and this species.

Boerhavia tetrandra Forst. f.

Ailinginae Atoll: Sifo I., 36685.

Common on sand and cobble flats.

Boerhavia sp.

Rongelap Atoll: Kabelle I., 36670; Gegen I., 36728. Rongerik Atoll: Eniwetak I., 36700.

Common to dominant in ground cover in open and thin forest. This is a white-flowered form with leaves resembling those of B. mutabilis R. Br., and its exact status is uncertain as yet. It is also known from Wake and Johnston Islands. It would ordinarily be referred to B. diffusa L. and may be what Taylor (1951) has reported under that name from the Marshall Islands. It was mentioned in the 1955 list from Wake.

*Bougainvillea glabra Choisy

Utirik Atoll: Utirik I., 36716. Likiep Atoll: Likiep I., 36629, 36631.

Several color forms planted around houses but not growing especially well.

Pisonia grandis R. Br.

Ailinginae Atoll: Sifo I., 36680.

Codominant with Cordia in the forest, as in other dry atolls in the northern Marshalls and Wake Island.

Achyranthes canescens R. Br.

Rongelap Atoll: Gegen I., 36730.

Rare in thin Pisonia forest.

Portulaca lutea Sol.

Rongerik Atoll: Eniwetak I., seen by Evans, but not collected.
Ailinginae Atoll: Sifo I., 36676.
Occasional in sandy openings.

Portulaca samoensis v. Poelln.

Rongelap Atoll: Rongelap I., 36658.
Very local in sandy soil in grassy opening in coconut plantation.

Cassytha filiformis L.

Ailinginae Atoll: Sifo I., 36689.
Occasional, parasitic on Guettarda.

*Delonix regia (Bojer) Raf.

Likiep Atoll: Likiep I., 36638.
Old tree, planted in garden.

*Leucaena glauca (L.) Benth.

Likiep Atoll: Likiep I., 36636.
Planted in garden.

*Mimosa pudica L.

Kwajalein Atoll: Kwajalein I., 36640.
Very local on disturbed ground near air-strip; plants very chlorotic.

Soulamea amara L.

Rongerik Atoll: Eniwetak I., 36706.
Small colony in Pisonia forest; new northernmost record in Marshall Islands.

Suriana maritima L.

Ailinginae Atoll: Sifo I., 36690.
Common locally in scrub.

*Euphorbia cyathophora Murr.

The plants reported in the 1955 list as Euphorbia heterophylla L. have been redetermined by Dr. R. L. Dressler as E. cyathophora.

*Euphorbia glomerifera (Millsp.) Wheeler

Reported in 1955 list as Euphorbia hypericifolia L. but probably better referred to E. glomerifera.

Euphorbia hirta L.

Utirik Atoll: Utirik I., 36717.
Several plants seen near landing.

*Pedilanthus tithymaloides (L.) Poit.

The variegated form of this is planted around houses on Kwajalein Iset.

*Phyllanthus amarus Schum. & Thonn.

Eniwetok Atoll: Eniwetok I., St. John 23,706. (US)
Reported in 1955 list as Phyllanthus niruri L., but that species has been shown by Dr. G. L. Webster not to occur in the Pacific. The plants so referred from the Marshall Islands have been redetermined by Webster to be P. amarus.

of value as a fertilizer, nitrogen deficiency may be one reason why some plants do not thrive on atolls. A number of other species were growing in the nursery, but were unfamiliar and not identifiable from the material seen. It is probable that a few of the species listed may eventually prove adapted to general cultivation in the Marshalls, but in all probability without special attention few of them will become established. It is reported that a selection of the nursery stock from Kwajalein has been taken to Eniwetok for planting there, but no information is yet available as to whether any of the plants have been successful.

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<i>Acalypha hispida</i>	<i>Clerodendrum inerme</i>
<i>Acalypha wilkesiana</i>	<i>Coccoloba uvifera</i>
<i>Aleurites moluccana</i>	<i>Cocos nucifera</i>
<i>Allamanda cathartica</i> var. <i>hendersonii</i>	<i>Codiaeum variegatum</i>
<i>Allium fistulosum</i>	<i>Coffea arabica</i>
<i>Alocasia macrorrhiza</i>	<i>Coleus scutellaria</i>
<i>Alpinia purpurata</i>	<i>Cordia sebastena</i>
<i>Ananas comosus</i>	<i>Cordyline australis</i>
<i>Angelonia angustifolia</i>	<i>Cordyline terminalis</i>
<i>Anthurium</i> sp.	<i>Cordyline</i> sp.
<i>Apium graveolens</i>	<i>Crinum asiaticum</i>
<i>Apium petroselinum</i>	<i>Cryptanthus zonatus</i>
<i>Araucaria excelsa</i>	<i>Cryptostegia grandiflora</i>
<i>Argyrea</i> sp.	<i>Cucumis melo</i> var.
<i>Artocarpus altilis</i>	<i>Cucumis sativus</i>
<i>Asparagus sprengeri</i>	<i>Cucurbita pepo</i>
<i>Asplenium nidus</i>	<i>Cucurbita</i> sp.
<i>Asystasia gangetica</i>	<i>Cymbidium</i> sp.
<i>Barleria cristata</i>	<i>Cycas circinalis</i>
<i>Barringtonia asiatica</i>	<i>Daucus carota</i>
<i>Bauhinia</i> sp.	<i>Delonix regia</i>
<i>Begonia</i> sp.	<i>Dieffenbachia</i> sp.
<i>Beloperone guttata</i>	<i>Duranta repens</i>
<i>Bougainvillea spectabilis</i>	<i>Epidendrum</i> sp.
<i>Brassica actinophylla</i>	<i>Epipremnum pinnatum</i>
<i>Brassica napus</i>	<i>Erythrina variegata</i> var. <i>orientalis</i>
<i>Brassica oleracea</i>	<i>Euphorbia cyathophora</i>
<i>Brassica pekinensis</i> ?	<i>Euphorbia nereifolia</i>
<i>Breynia nivosa</i>	<i>Euphorbia pulcherrima</i>
<i>Caladium bicolor</i>	<i>Ficus rubiginosa</i>
<i>Calophyllum inophyllum</i>	<i>Ficus microphylla</i>
<i>Canna indica</i>	<i>Gardenia jasminoides</i>
<i>Capsicum annum</i>	<i>Gliricidia sepium</i>
<i>Carica papaya</i>	<i>Gomphrena globosa</i>
<i>Cassia alata</i>	<i>Guettarda speciosa</i>
<i>Casuarina equisetifolia</i>	<i>Hedychium coronarium</i>
<i>Catharanthus roseus</i>	<i>Hemigraphis</i> sp.
<i>Cerbera</i> sp.	<i>Hernandia sonora</i>
<i>Chrysolidicarpus lutescens</i>	<i>Hibiscus mutabilis</i>
<i>Cibotium</i> sp.	<i>Hibiscus rosa-sinensis</i>
<i>Citrullus vulgaris</i>	<i>Hibiscus schizopetalus</i>

Hibiscus tiliaceus	Scindapsus aureus
Hibiscus (ornamental hybrid)	Sesuvium portulacastrum
Hymenocallis littoralis	Solandra sp.
Ipomoea batatas	Solanum lycopersicum
Ixora casei	Strelitzia reginae
Jasminum pubescens	Tabebuia pentaphylla
Kalanchoe pinnata	Tabernaemontana coronata
Lactuca sativa	Theophrastia sp.
Lagerstroemia indica	Thespesia populnea
Macadamia ternifolia	Thevetia peruviana
Merremia tuberosa	Vanda "Miss Joachim"
Mirabilis jalapa	Vitex trifolia
Morinda citrifolia	Zea mays
Murraya paniculata	Zinnia elegans
Musa sapientum	
Nephrolepis hirsutula	
Nerium oleander	
Nerium sp.	
Ochrosia oppositifolia	
Osteomeles anthyllidifolia	
Pandanus tectorius	
Passiflora edulis	
Pedilanthus tithymaloides	
Pemphis acidula	
Pentas lanceolata	
Persea americana	
Petraea volubilis	
Philodendrum oxycardium	
Phoenix sp.	
Phyllodendron sp.	
Pilea microphylla	
Pisonia grandis	
Plumeria obtusa	
Plumeria rubra	
Podocarpus sp.	
Polypodium scolopendria	
Polyscias fruticosa	
Polyscias guilfoylei	
Polyscias scutellaria	
Polyscias tricochleata	
Polyscias sp.	
Pritchardia sp.	
Pseuderanthemum carruthersii var. atropurpureum	
Pseuderanthemum carruthersii var. carruthersii	
Pseuderanthemum carruthersii (var. with yellow veins)	
Ptychosperma macarthuri	
Raphanus sativus	
Ravenala madagascariensis	
Rhapis flabelliformis	
Rhoeo spathacea	
Ruellia longifolia	
Russelia equisetiformis	
Sansevieria roxburghii	
Scaevola sericea	
Schinus terebinthifolius	

ATOLL RESEARCH BULLETIN

No. 69

Contribution to a German Reef-Terminology

by

Georg Scheer

Issued by

THE PACIFIC SCIENCE BOARD

National Academy of Sciences--National Research Council

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May 15, 1959

Contribution to a German Reef-Terminology

by

Georg Scheer^{1/}

In Germany recent publications on coral reefs are lacking due to isolation before, during, and after the war. The younger generation of zoologists has had no opportunity to undertake expeditions to tropical seas. But the interest in coral reefs and their inhabitants has always been keen in Germany.

Dr. Hans Hass, the founder of the International Institute for Submarine Research, Vaduz (Liechtenstein), has placed his research ship, the yacht "Xarifa" at the disposal of science. In 1953-54 he carried out an expedition to the Caribbean Sea and to the Galapagos Islands in the Eastern Pacific. He led another expedition in 1957-58 to the Red Sea and to the Maldive Islands in the Indian Ocean. I am much obliged to Dr. Hass for giving me the opportunity to take part in both expeditions.

During both voyages we were diving with oxygen and compressed-air diving equipment. In this way we were able to study the coral reefs in their many aspects by direct observation. We worked in a team, one collecting fishes, others making behavioural studies and so on. Dr. Hass and I were particularly interested in the formation of coral reefs and in the sociological composition of their different parts.

Soon we realized the necessity to use a clearly defined nomenclature for the different parts of a coral reef, and to coordinate this German nomenclature with the English one. After long discussions with the other members of expedition (Dr. Hans Hass; Prof. Dr. W. Luther, director of the Zoological Institute of the University Darmstadt; Dr. I. Eibl-Eibesfeldt, Max Planck-Institute for Verhaltensphysiologie, Seewiesen; Dr. L. Franzisket, director of the Museum of Natural History, Muenster; Dr. S. Gerlach, Zoological Institute of the University Kiel; and Dr. W. Klausewitz, Research Institute and Museum Senckenberg, Frankfurt a.M.) may I present in the following lines a few German terms with English equivalents. They concern mainly atolls, but they are applicable in like manner to all other reefs. This terminology does not go for the present into details, but handles only the great striking characteristics of reefs.

The following list contains mostly translations of English expressions, because there are not such far-reaching subdivisions of coral reefs in the older German publications. I take as basis for the terminology the publications of Tracey, Cloud and Emery: "Conspicuous Features of Organic Reefs"^{2/}, of Harry: "Ichthyological Field Data of Raroia Atoll, Tuamotu Archipelago"^{3/}, and of Kuenen: "Classification of Reefs and their Component Parts"^{4/}. All these publications include figures illustrating the English names mentioned in this paper.

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1. Zoological Department, Hessisches Landesmuseum, Darmstadt, Germany.
 2. Atoll Research Bulletin No. 46, 1955
 3. Atoll Research Bulletin No. 18, 1953, p. 21-26
 4. Marine Geology, New York 1950, chapter 6: Coral Reefs, p. 423-430

REEFS IN GENERAL

fringing reef
barrier reef
atoll
reef grown up independently in
lagoons of barriers and atolls
drowned reef
uplifted reef

SEAWARD REEF

outer slope
terrace
bench or shelf
under-reef cavern
reef front

surge channel
surge zone
surf zone

buttress
groove and buttress-system
reef margin
algal ridge

RIFFE; ALLGEMEIN

Kuestenriff or Saumriff
Wallriff or Barriereriff
Atoll
Fleckenriff or Flachseeriff
ertrunkenes Riff
gehobenes Riff

AUSSENRIFF

Aussenabhang, if the slope is not
too steep;
Aussenwand, if the slope is steep,
about 70 to 90° to level

Terrasse, a broad, little inclined
step in the slope

Absatz, a small terrace, interrupt-
ing the slope

Hoehle, great cavern;
Grotte, small cavern

Riffabhang;
Riffwand, the strongly inclined
part of the slope, which is more
or less covered with living
corals

Brandungsrinne

Wellenzone, the outward part of a
surge channel

Brecherzone, the inner, landward
part of a surge channel

(Wellenzone and Brecherzone together
are the Brandungszone)

Riegel

Rinnensystem

Riffkante

Lithothamnionwall

REEF FLAT

seaward edge

tidepool

a sandy zone in shallow water
in front of the coast

inter-island channel

ISLAND

seaward beach

shingle rampart

boulder rampart

beachrock

lagoon beach

LAGOON REEF FLAT

a sandy zone in shallow water
between the island and the
lagoon

lagoon reef margin

lagoon reef face

LAGOON

lagoon slope

lagoon floor

coral head, knoll, or mound

Acropora thicket

tall narrow pinnacle

patch reef

miniature atoll

RIFFPLATTE

Aussenkante

Fluttuempel

seeseitige Seichtwasser-Sandzone

Riffkanal

INSEL

Aussenstrand or Meeresstrand

Geroell-Strandwall

Block-Strandwall

Strandsandstein

Lagunenstrand

LAGUNENRIFFPLATTE

lagunenseitige Seichtwasser-
Sandzone

Innenriffkante

Innenriffhang

LAGUNE

Innenhang

Lagunenboden

Korallenblock

Acroporenhecke

Turm

Buckelriff or Korallenbuckel

Miniaturatoll, an atoll-shaped
patch reef with a ring of living
corals around a deeper flat cov-
ered with sand and dead, broken
corals

faro

Faro, an atoll-shaped reef of
greater extension with a dis-
tinct lagoon

This list may serve as a base for a more elaborated German reef terminology. With greatest interest we are looking forward to the Reef Terminology Index, which the Pacific Science Board of the National Academy of Sciences-National Research Council, Washington, D. C., is preparing.

ATOLL RESEARCH BULLETIN

No. 70

Atoll News and Comment

Issued by

THE PACIFIC SCIENCE BOARD

National Academy of Sciences--National Research Council

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May 15, 1959

ATOLL NEWS AND COMMENT

With this issue is started a series of informal articles by the editors of the Atoll Research Bulletin calling attention to expeditions to atolls and reefs, to record notes and observations that are too short to appear as separate numbers of the Bulletin, to call attention to and briefly review significant new publications, and to point out and emphasize important items from older publications pertinent to the modern study of coral atolls. The editors will welcome news notes, observations, and other items of interest that readers may care to send in, and will give the senders proper credit for any such used.

In the past the editors have gone to considerable trouble to ascertain correct addresses for people on the Bulletin mailing list who have moved or are reputed to have moved. We have decided that this is a fruitless waste of time. Hereafter, when a copy is returned the addressee's name will be removed from the list without further ado and will only be restored if he writes and requests it. This may make it possible to fill some of the many requests that must now be turned down.

ARB readers may be interested in the progress of the Pacific Science Board's Reef Terminology Index project. Since the Third Circular of the project, with a selected bibliography of the geological literature on reefs almost half of the papers on reef geology have been examined and about 1400 definitions and usages have been abstracted. The remaining geological papers have been assigned to members of the International Committee for examination. A bibliography of the principal papers on reef ecology, botany, and zoology is in preparation. The aim of this program is to bring together the terms in English applied to reef features, their original definitions and differing later usages, foreign language equivalents, principal genera of organisms found in and on reefs and atolls, locations and brief characterizations of classical reefs, and any other information that will possibly lead to clearing up the mess in which terminology referring to reefs and atolls finds itself. Cooperation on this project is earnestly invited. Correspondence may be addressed to the ARB editors.

We are glad to bring to the attention of the readers of the Atoll Research Bulletin the International Institute for Submarine Research, Vaduz, Liechtenstein, with its floating biological laboratory, the research vessel "Xarifa". This vessel is equipped to carry eight scientists and is fully self-contained and capable of carrying out many types of marine biological research as well as other types of scientific work on islands and coast-lines that are hard to reach by ordinary means. In 1958, work was carried out in the Maldives, and future programmes call for work out of northern Australia into the Molucca, Philippine, and Caroline Islands. Cooperation is invited from other interested institutions in expeditions on a semi-annual and annual basis. The president of the Institute is Dr. Hans Hass, the scientific director, Dr. Irenäus Eibl-Eibesfeldt. They are supported by a Committee for the Exploration of Tropical Seas and Islands, made up of internationally known scientists from the fields of Zoology, Anthropology, Ethnology, Geophysics, Paleontology, Geology, and Botany.

The Pacific Naturalist, published by the new Beaudette Foundation for Biological Research, Box 227, R.F.D. 1, Solvang, California, U.S.A., is the latest addition to the assortment of journals in which the results of research on coral atolls may appear. This serial, of which five numbers have appeared since its initiation, Dec. 17, 1958, is handsomely printed, beautifully illustrated, and will appear irregularly as a medium for publication of the results of the work of the Beaudette Foundation. We take occasion to welcome this new institution into the Pacific science community, and hope that its "program of inquiry into the systematics, distribution and utilization of marine and littoral organisms, particularly the plants, of the eastern tropical and subtropical Pacific" may prosper. The first five papers, including the one reviewed below are a good start. The president of the Beaudette Foundation is Palmer T. Beaudette and its scientific director is our friend E. Yale Dawson.

Mr. Bernd Lambert, of Sydney, Australia, writes that he will leave shortly for approximately 13 months of anthropological field work in the northern Gilbert Islands under a grant from the Tri-Institutional Pacific Program.

Recent Expeditions to Atolls

While it is probable that the resident scientist, in any region, may eventually achieve deeper understanding of his environment than does the expedition scientist, the geographical facts of life seem to indicate that most scientific work on coral atolls will, for some time to come, be done by expeditions. The very limitation of time inherent in expedition work may well have its beneficial aspects. The knowledge that time is limited, the novelty of the situation, and, often, the company of the members of the expedition may all have the effect of stimulating the expedition scientist, both mentally and physically, and on a successful expedition a prodigious amount of work may be accomplished.

Most readers of the Atoll Research Bulletin are either past or potential members of expeditions to coral atolls. They may be interested in brief notes about recent expeditions to atolls, the results of which are not yet available in published form.

Maldiv Islands: Dr. Georg Scheer writes that the Xarifa (see above) spent some months in the Indian Ocean, concentrating in this group of atolls, under the direction of Dr. Eibl-Eibesfeldt. Large collections of marine animals and birds were made and direct observation was carried out by means of under-water equipment.

Jaluit Atoll: After the visit of disastrous typhoon Ophelia, a Pacific Science Board expedition, under ONR sponsorship, spent a week on the atoll to study the effects of this typhoon. The party, under the leadership of David I. Blumenstock, consisting of A. H. Banner, F. R. Fosberg, J. L. Gressitt, E. D. McKee, J. B. MacKenzie, and H. J. Wiens, collected substantial amounts of data on what the storm did to the physiography, soils, fauna, flora, vegetation, and human life on the atoll. This will make a substantial contribution toward understanding the role of typhoons in the ecology and geomorphology of atolls in general. For a first preliminary announcement of results see Nature 182: 1267-1269, 1958.

Tuamotus: Dr. Jacques Barrau, Plant Introduction Officer of the South Pacific Commission, recently spent some weeks in the Tuamotus and is currently in Micronesia, where he has visited several atolls among the other islands. He is actively collecting and studying the forms of breadfruit in an attempt to understand the origin and migration of the many horticultural varieties. Important light may be shed on the prehistoric migrations of the Pacific peoples, in addition to solving the obvious botanical problems.

Clipperton Island: As an adjunct to the DOLDRUMS Expedition of the Scripps Institution of Oceanography last summer a party of biologists spent several weeks making a scientific survey on Clipperton Island, a ring-shaped coral island, like an atoll except for a snag of volcanic rock sticking up on one side. This island is of great interest in that it is one of the most isolated of all coral atolls and the only one in the eastern Pacific. Its biota is extremely impoverished. The ARB assistant editor was enabled to serve as botanist and geologist of the expedition through the kind invitation of Scripps Institution and financial assistance from the Joseph Henry Fund of the National Academy of Science. Some of the results may be expected in an early issue of ARB.

Canton Island: Under the auspices of the Civil Aeronautics Administration (now the Federal Aviation Agency) Dr. and Mrs. Otto Degener revisited Canton Island in early 1958 to inspect the results of attempts at revegetation carried out in 1950 and 1951 (see ARB 41-43). Part of the results are reported elsewhere in this issue.

Rongelap Atoll: During late February and early March, 1959, a Brookhaven National Laboratory party under Dr. Robert A. Conrad visited Rongelap Atoll for the yearly examination of the Marshallese people who were affected by radioactive fallout in 1954. Dr. Baruch S. Blumberg, a member of the party, during his free time made valuable observations for the Pacific Vegetation Project in connection with the possible long-term effects of fallout on plants. The notes collected will be made available in this issue or the next of ARB. While on Rongelap the party enjoyed the company and cooperation of a party from the University of Washington Applied Fisheries Laboratory, under Mr. Edward Held, carrying out their semiannual resurvey of radioactivity under the AEC program. This has now evidently expanded to include serious work on the land environment, with investigations of soil radioactivity. Dr. Frank Richardson was studying the birds of the atoll.

Current Literature

Geology of Kapingamarangi Atoll, Caroline Islands, by Edwin D. McKee, Bull. Geol. Soc. Amer. 69: 241-278, 1958; and Sedimentary Belts in lagoon of Kapingamarangi Atoll, by Edwin D. McKee, John Chronic, and Estella B. Leopold, Bull. Amer. Assoc. Pet. Geol. 43: 501-562, 1959. It is a pleasure to be able to report two excellent papers embodying the final results of the geological and soils investigations made on the Pacific Science Board expedition to Kapingamarangi, 1954. In addition to what might be expected in geological reports, much information of an ecological nature, soil chemistry, a diatom flora, reports of pollen and dinoflagellates, and of recent foraminifera are included. Comparisons are made with geologically ancient reefs.

A Review of Ciguatera, Tropical Fish Poisoning, with a Tentative Explanation of its Cause, by J. E. Randall, Bull. Marine Sci. Gulf and Carib. 8: 236-267, 1958, will be of great interest to atoll students, as poisoning from eating reef fishes is a widespread hazard on atolls. Jack Randall has advanced what seems to be the first reasonable suggestion as to the cause of this poisoning. He suggests that the fish may acquire the toxin from eating blue-green algae that characterize the pioneer vegetation on newly denuded substrata. This would account for the seemingly inexplicable inconsistency in the toxicity of the same species of fish at different times and places.

Changes in Palmyra Atoll and its Vegetation through the Activities of Man, 1913-1958, by E. Yale Dawson, Pacific Naturalist, 1(2): 1-51, 1959, is a most interesting paper, handsomely presented. The destructive character of the influence of man is as appalling on Palmyra as in most other places. Interesting is the fact that interference with the circulation of sea water in and out of the lagoon resulted in complete destruction of the lagoon biota. The quick recovery of the land vegetation is a phenomenon also observed elsewhere on atolls. The complete lists of land and marine plants collected are valuable. Dawson also makes the suggestion that the pioneer blue-green algae, especially Lyngbya, have something to do with the sudden appearance in 1943 of Ciguatera or poisoning from eating reef fishes (see Randall article noted above).

Dating the latest movements of the Quaternary sea level, by Rhodes W. Fairbridge, Trans. N. Y. Acad. Sci. II, 20: 471-482, 1958, furnishes a welcome review of recent data on eustatic sea level fluctuations. An understanding of these fluctuations and their chronology and amplitude is a necessity to one who would think broadly on the theories of the origins of atolls, on their surface geology, or on their land ecology. Data on recent attempts to date some of the fluctuations by radiocarbon methods makes it possible to have a bit more confidence in actual figures on the postglacial lowerings of sea level that provided most of the land surface on atolls.

Flora of the Hall Islands, by Benjamin Stone, Pac. Sci. 13: 88-104, 1959, gives brief descriptions of the vegetation and a list of the known species of vascular plants of this group of atolls in the northern part of the Carolines. This paper will help materially in filling out the gaps in our knowledge of the Caroline atolls, mostly to date very poorly known.

The Ecology of Jamaican coral reefs I. Species composition and zonation, by Thomas F. Goreau, Ecology 40: 67-90, 1959, is comprehensive, well illustrated, and will contribute significantly to an understanding of the coral reefs and islands in the West Indies.

The Elepaio, vol. 19, no. 9, has two articles on atoll birds, an account of blue-gray noddies and of white throated storm petrels on Christmas Island, by M. D. Gallagher, and one of the old-squaw duck on Midway by E. H. Bryan. It is of interest that the nesting habits of the blue-gray noddy (Procelsterna) on Christmas do not match exactly those seen on Bikar and Pokak Atolls in the Marshalls.

It may be appropriate here to call attention to the many valuable articles on atoll birds and atoll ecology scattered through the 19 volumes of Elepaio. This publication of the Hawaiian Audubon Society must be regarded as an important source of information on atolls, especially the Hawaiian ones.

Coral Island, by Marston Bates and Donald P. Abbott, 1-254, Scribners, N.Y., 1958, is an example of popular science writing at its best. The authors give an informal account of the Pacific Science Board expedition to Ifaluk, a portrait of an atoll, an autobiographical account of scientists at work, and a liberal introduction to scientific natural history, in a book as easy to read as a light novel. Highly recommended reading is the chapter on The Reefs. Here is much of the essence of marine ecology. Here, also, is reassurance to the reviewer as to the adequacy of his education as a biologist--he has had the two requisites for its completeness, opportunities to study both coral reefs and tropical rain forests. Not the least of the virtues of this volume is the sharing with the reader of the authors' scientific philosophies.

Marine Ecology, by H. B. Moore 1-493, Wiley, 1958, is a comprehensive book, reviewing much of the important work that has been done in the field of marine ecology and boiling it down to the point where it is possible to assess the field. It is essentially a review, and throughout the text the sources of the material summarized are faithfully cited. For this very reason the book is really not very well adapted for use as a text book except for very advanced courses. It is not smooth or easy reading. Rather it is a compendium of information so arranged that what is available on almost any type of marine environment and its inhabitants may be readily located.

The coral reef environment is treated at somewhat less length than that allotted to some of the others, but the discussion is an important summary, emphasizing depth, light, and temperature limitations. Of especial interest is the attention given the zooxanthellae, or intracellular algae found in reef corals and other organisms. The illustrations of reef communities are especially striking, mostly taken from Manton and Stephenson's work on the Great Barrier Reef. Reefs such as those found in the Central Pacific that are largely algal in nature, receive scant attention.

The ecological framework around which the book is built is that of the marine environment, its subdivisions and its gradients. Ecological behavior, life histories, and differing requirements of larval and adult stages are properly emphasized. Analysis of data is done very thoroughly, synthesis scarcely attempted. Curiously, the term ecosystem is completely absent, nor is any equivalent used or proposed. Intracommunity relationships are discussed at length throughout the book, and dynamics are stressed here and there. The viewpoint, however, seems to be basically autecological. This seems true, at least if one regards the cited and quoted material as indicative, in spite of the fact that the author in his introduction emphasizes the necessity for integration (of the results of autecology and synecology). He even coins the term "integral ecology" for a third subdivision which he regards as coordinate with autecology and synecology. Perhaps some of his readers may fail to see the difference between "integral ecology and synecology".

One may also wonder if the author's question whether the autecologist's study of individuals can ever adequately describe communities as they occur under natural conditions, on p. 419, means that he thinks the ultimate objective of autecology is to describe communities. He also, on the same page, betrays some vagueness on the matter of what indicates that the community is more than the sum of its parts. No mention is made of effects caused by the community that could not conceivably result from its members separated in space or not organized in the way that the community is organized. Organization of communities is scarcely stressed at all in the book. Land ecologists will wonder if the lack of emphasis on climax and his statement on p. 420 that at no time are we dealing with a really stable climax condition is an indication of the author's bias or if such stability in communities as is observed on land simply does not exist in the sea.

Moore, in this book, has presented a magnificent accomplishment in bringing such a vast array of data into such order that it may be examined. Reef specialists will be disappointed in the scant attention given their part of the marine field. However, all of them will find the book extremely useful and interesting. Not the least useful feature will be the 27 pages of bibliography and the classified list of the genera referred to in the text.

It is a pity that as much cannot be said for the editing as for the compilation itself. Typographical errors abound, including some in the bibliography. For example Anton Bruun's name is spelled Braun on p. 211 and Bruan on p. 431. The most annoying thing of all, however, is the frequent reference to organisms by binomials with the generic name reduced to its initial. This is entirely proper if the genus has been spelled out earlier on the page, but in literally dozens or perhaps hundreds of cases one looks back a long way for the full binomial. For example, L. littorea on pp. 22 and 36 refers back to Littorina littorea on p. 21, although Lopholatilus and Laminaria are both referred to on pp. 21 and 22. In general far more familiarity with individual organisms is assumed than is warranted. This is partly offset by the list of genera of organisms referred to arranged according to the taxonomic system on pp. 421-428, with cross references from the index. Mention of this cross referencing scheme in the preface would have saved valuable time spent in discovering it. A glossary would have helped, especially where such words as "systrophe" (p. 153) and "implode" (p. 251) are used. However, far less unfamiliar words and usages are found here than is usual in ecological works.

Older Literature

It is interesting to note, on rereading Charles Darwin's description of Keeling Island in his Journal of Researches (London, 1839, pp. 539-553), that in addition to his many other great discoveries and generalizations he pointed out the essential principle of what has since been called the Ghyben-Herzberg fresh-water lens and that this was first noticed on an atoll islet. He says (pp. 545-546), "On this island the wells are situated from which ships obtain water. At first sight it appears not a little remarkable that the fresh water should

regularly ebb and flow with the usual tide. We must believe that the compressed sand or porous coral rock acts like a sponge; and that the rain water which falls on the ground being specifically lighter than the salt merely floats on its surface, and is subject to the same movements. There can be no actual attraction between salt and fresh water, and the spongy texture must tend to prevent all admixture from slight disturbances. On the other hand, where the foundation consists only of loose fragments, upon a well being dug, salt or brackish water enters; of which fact we saw an instance on this same island."

Additional note

A specimen of scarab collected on Male Atoll in the Maldives Islands in 1956 by F. R. Fosberg has just been identified by Dr. Oscar Cartwright, of the Division of Insects of the U. S. National Museum as Oryctes rhinoceros (L.), the rhinoceros beetle which destroys coconut trees. At the time this specimen was collected none of the characteristic signs of the ravages of this beetle were noticed in the coconut palms of Male Atoll, so it is probable that it had only been recently introduced. If this pest has become established in the Maldives it could prove to be a major disaster to the economy of the islands, which is largely dependent on the coconut palm. It is recommended that local authorities endeavor to determine if the rhinoceros beetle has become established, and that if it has vigorous efforts be made to eliminate it, before the infestation reaches major proportions. A campaign to destroy all dead palms and other decaying vegetable trash which might serve as a breeding place would be a good start.

Editors

